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Studying Soil

METRIC EDITION

William MacKillican

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Studying Soil

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Studying Soil

METRIC EDITION

William MacKillican, B.A., M.Ed.

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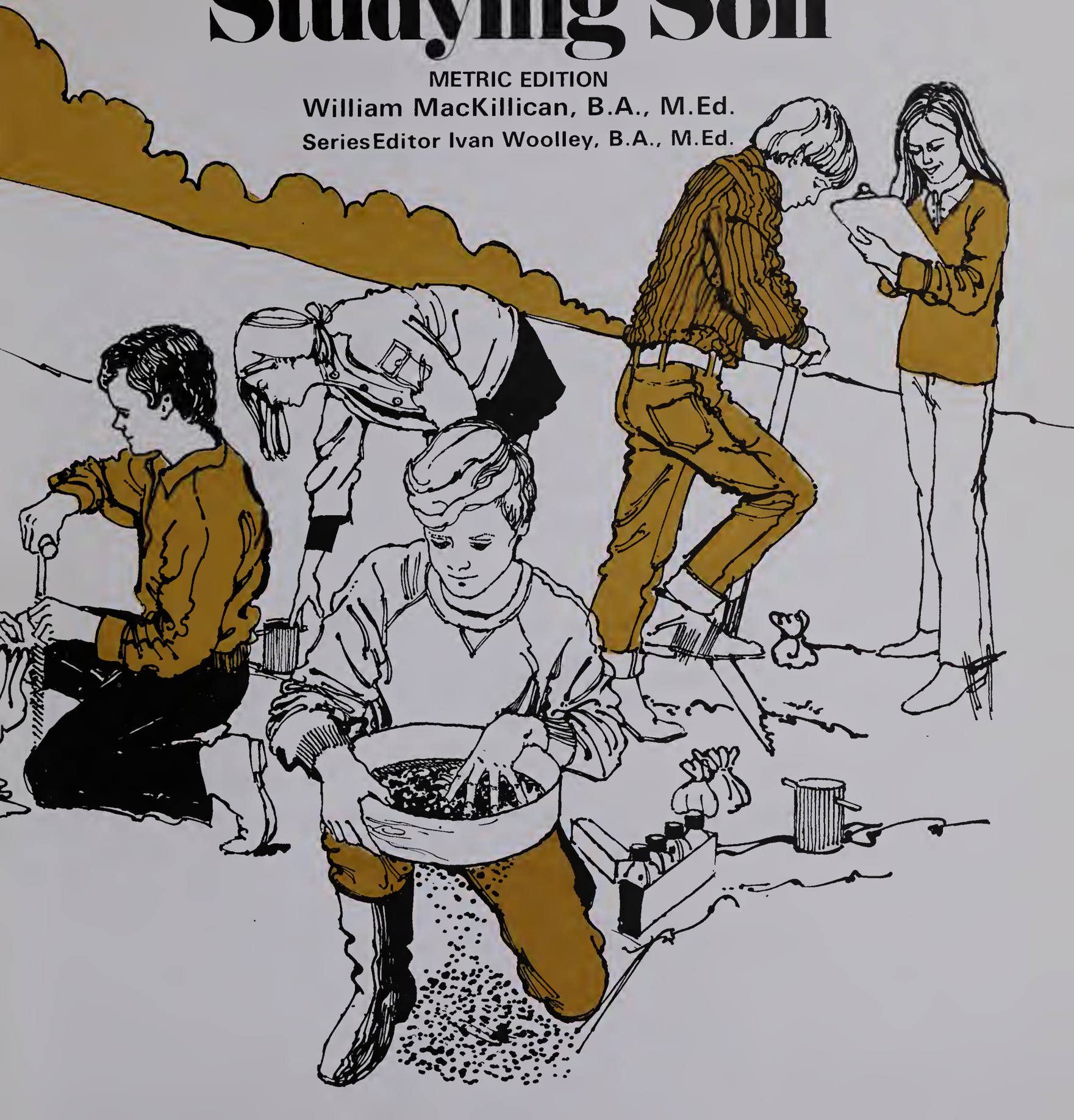

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ISBN 07-077710-1

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Printed and bound in Canada
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The author wishes to express appreciation to teachers and pupils who assisted in the preparation of this book. Several pupils donated some of their work prepared during testing of the manuscript. Teachers who assisted with evaluating the manuscript included Mike Carlon, Eila Rinaldo, Allison Peden, Dave O'Neil, Joan Phillips, Emerson Sova and Wayne Hopkins.

The author is also indebted to John Opper who made helpful comments after reading the final revision, and to Carol MacKillican who assisted many times with revisions and proofreading during the preparation of the original materials.

W.S.M.

The author has wide experience in outdoor education in Canada, as a teacher, principal and consultant.

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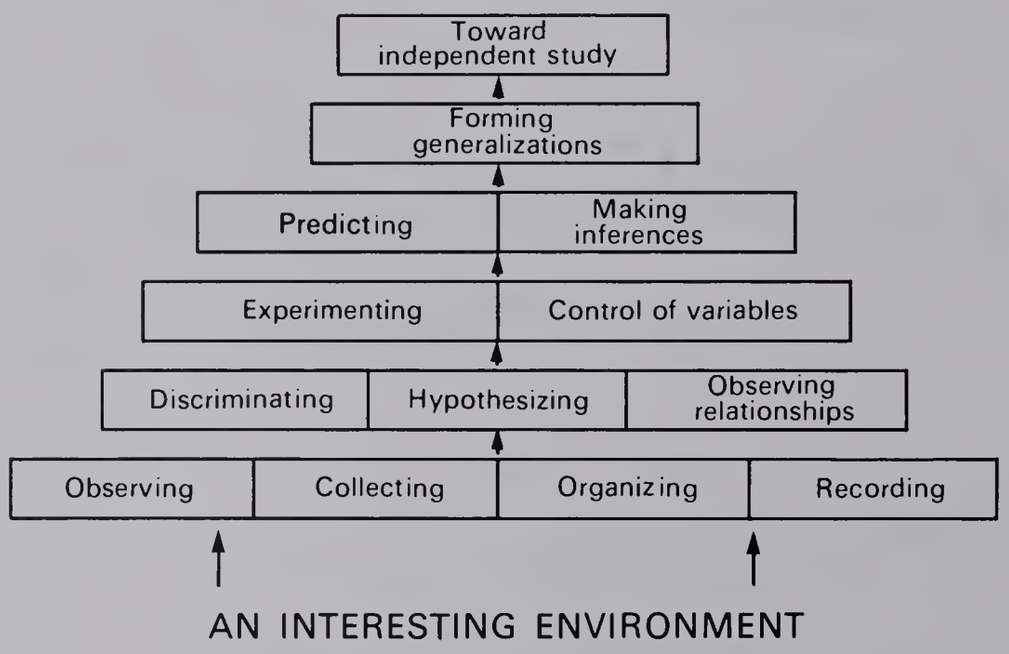
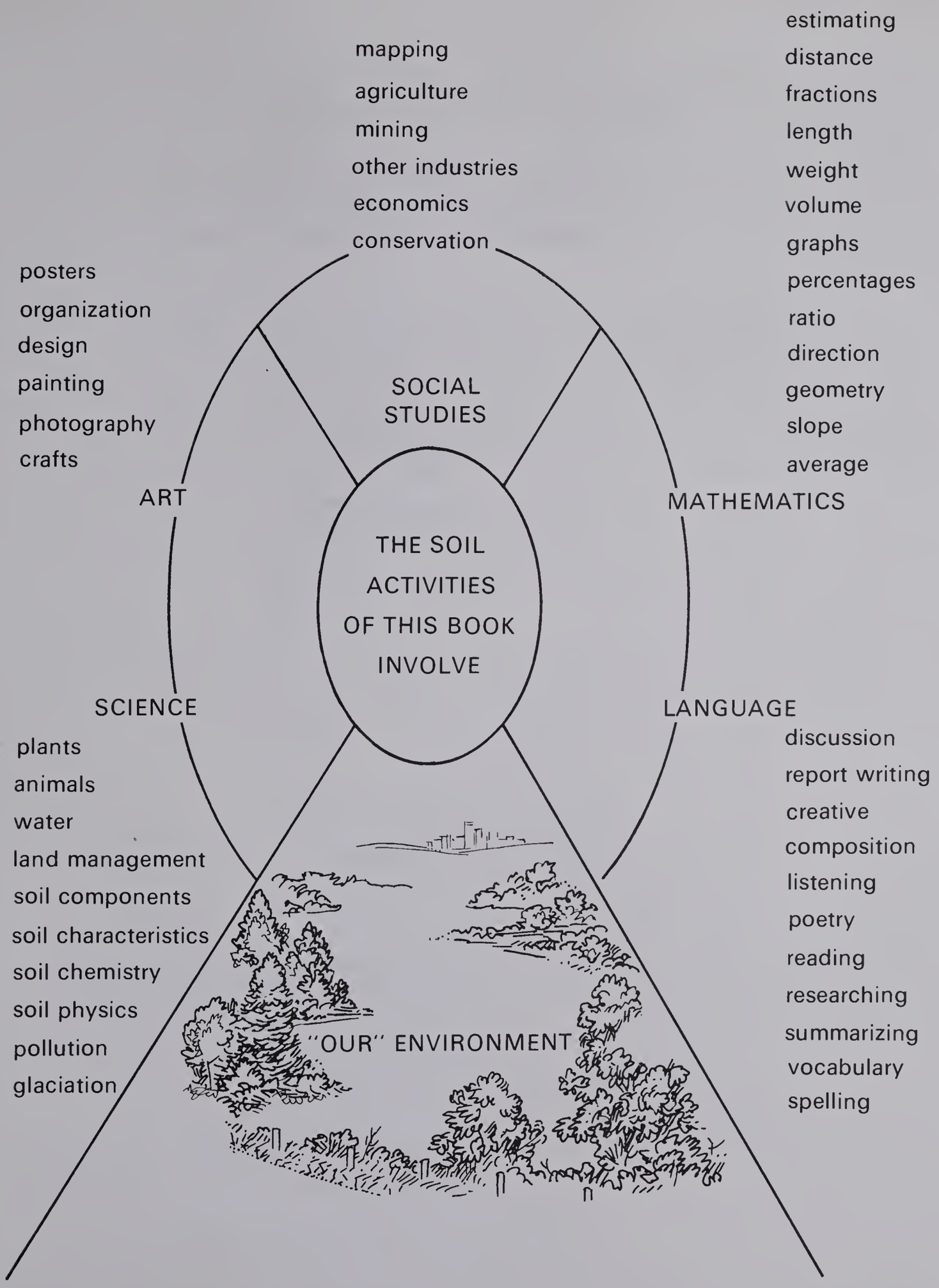
TO THE TEACHER

The outdoors is now widely recognized as an ideal laboratory to supplement in-school study, and the activities of this book on soils are designed to lead pupils into a wide variety of enquiries and subject disciplines. They were tested before publication, and the pupils' enthusiastic responses to this active and personal approach to learning were most encouraging. Pupils and their teachers used the activities as starting points to develop inter-disciplinary approaches to learning. Some of this integration will be evident as you survey the book.

The relationship of skills chart shown below served as a framework for organizing the activities.

A Relationship of Skills

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mining
other industries
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conservation
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distance
fractions
length
weight
volume
graphs
percentages
ratio
direction
geometry
slope
average
MATHEMATICS
posters
organization
design
painting
photography
crafts
ART
THE SOIL ACTIVITIES OF THIS BOOK INVOLVE
SCIENCE
plants
animals
water
land management
soil components
soil characteristics
soil chemistry
soil physics
pollution
glaciation
LANGUAGE
discussion
report writing
creative composition
listening
poetry
reading
researching
summarizing
vocabulary
spelling
"OUR" ENVIRONMENT

Dear Pupil:

Welcome to this book! I hope you will find the many activities interesting and enjoyable. They are planned so that you will be experimenting and inquiring both indoors and out. The activities will vary in length and difficulty and you will sometimes have to use teamwork to solve some of the problems. Though all the ideas are related to soil, it will be necessary to use many subjects as you work through the material.

Soil Studies has 10 chapters. These contain many activities to help you learn some of the main characteristics of soil. Because there are many exercises you will likely want to spread the work out over more than one year and share your efforts with classmates. Before beginning your studies, quickly look at the whole book to answer the following questions.

1. *How can the table of contents be used as an introduction to the book?*

2. *What headings are contained in each chapter?*

3. *How can the drawings and pictures be used to give you an overall idea of the content?*

4. *How many different ways of recording are there?*

5. *What work was done by other pupils?*

6. *Why was the "appendix" included?*

I hope that these questions will lead you to the first of many interesting discussions and inquiries about soil. If you wish to share your ideas and findings, as you work with this book, I would be pleased to receive a letter from you.

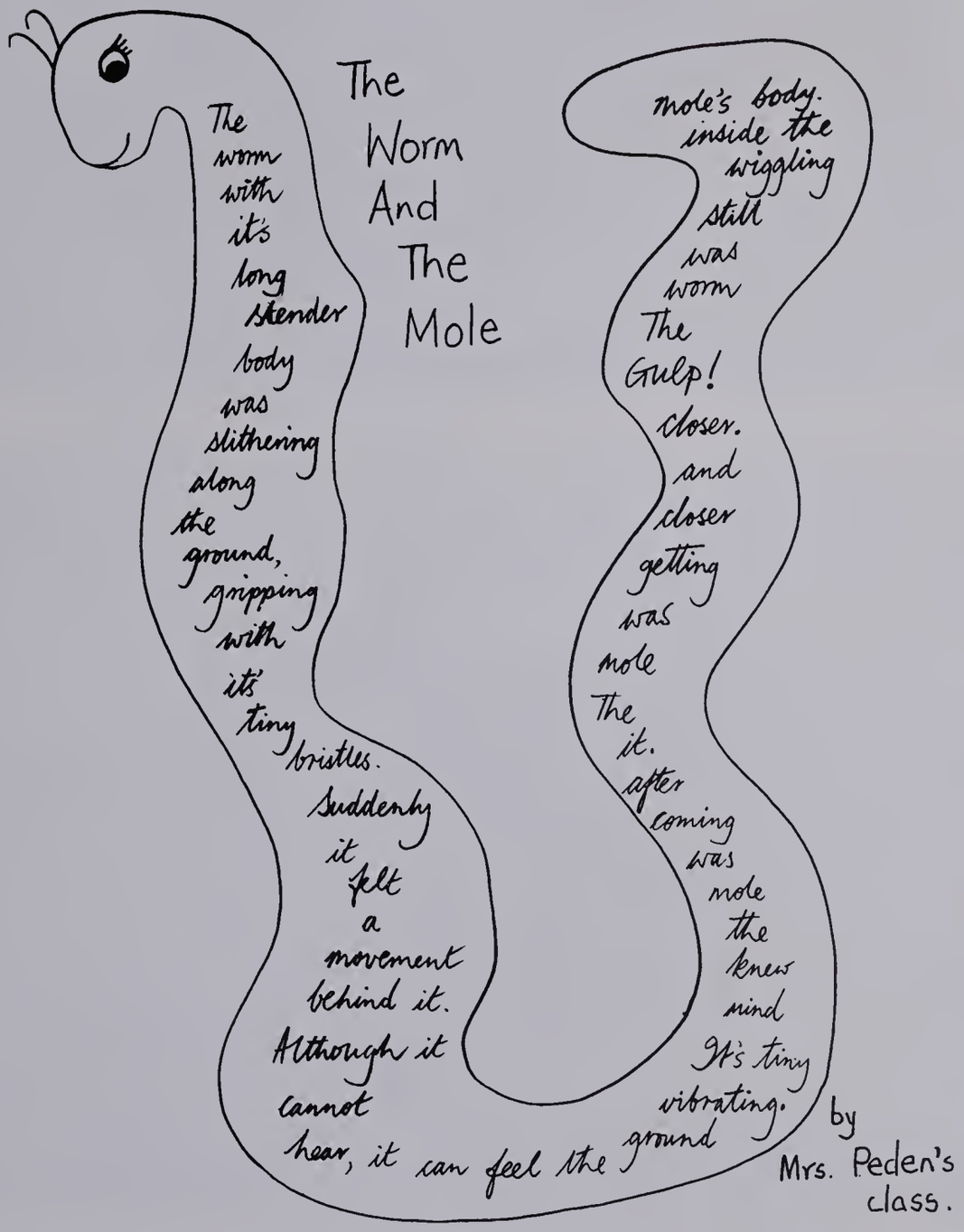
Yours sincerely,

William MacKillican

William MacKillican

WORKING WITH SOIL

The next few pages contain work done by pupils as they tested the activities in this book before it was published. Take a good look: perhaps you will get some worthwhile ideas.


The Worm And The Mole
The worm with it's long slender body was slithering along the ground, gripping with its' tiny bristles. Suddenly it felt a movement behind it. Although it cannot hear, it can feel the ground
mole's body. inside the wiggling still was worm The Gulp! closer. and closer getting was mole The it. after coming was mole the knew mind It's tiny vibrating.
by Mrs. Peden's class.

The Caves

There are many explanations to explain the gloomy caves on Ski Club Road. Some think they were caused by water erosion while others say the cause was an earthquake. We think they were caused by the hill-hag gods.

These gods are sinister creatures who are half human with bat-like claws and monstrous wings. Every 5 000 years they dig their way to the surface and then return to their hidden depths below airport hill. We don't know why they do these strange things but we can make some guesses. Perhaps they dig tunnels to let air in for their strange leader Macelinea; maybe they just get restless or possibly they come to the surface to temporarily escape the underground heat.

Maybe some of our descendants will find the answer.

Deborah Snowdon (age 11)
Adrienne Manning (age 12)

Soils We Found

Chapter 1

WHAT IS HAPPENING TO OUR SOIL?

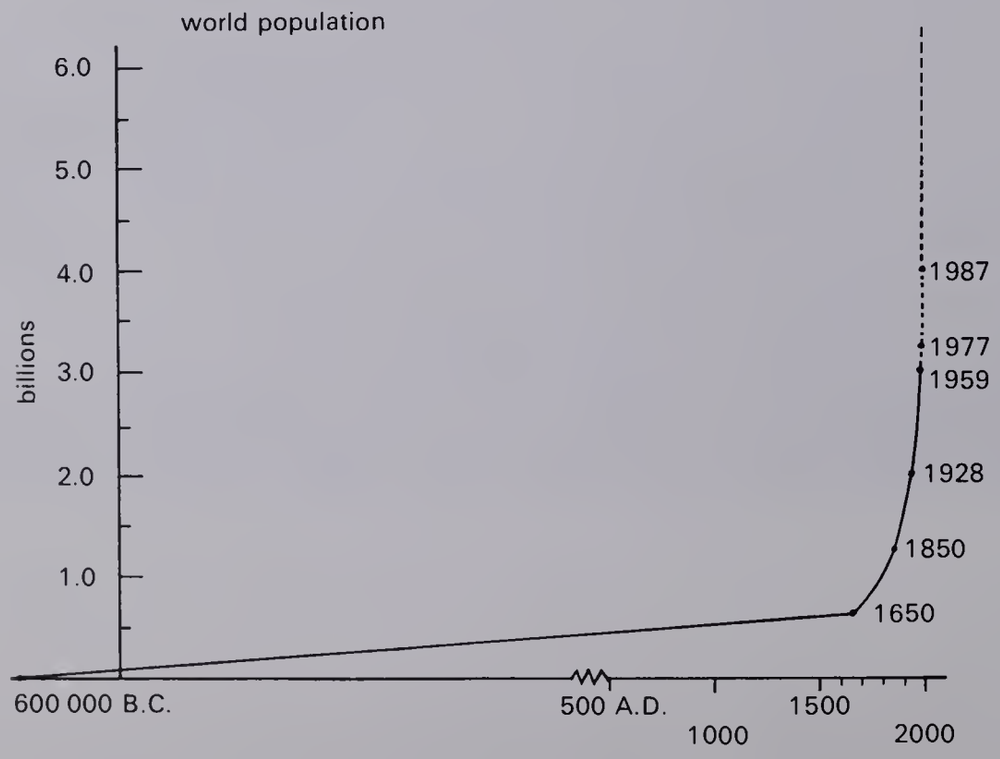
Soil is so common that we usually take it for granted. It may blow in our eyes, track into our homes and help to provide us with food, but we rarely give it serious thought.

Perhaps this book will make you think more carefully about soil. This first chapter will begin to give you an idea how important it is. Each of the following chapters explores different factors of soil in detail, to help you understand why this common substance is so vital to us all. Have fun!

THE IMPORTANCE OF SOIL

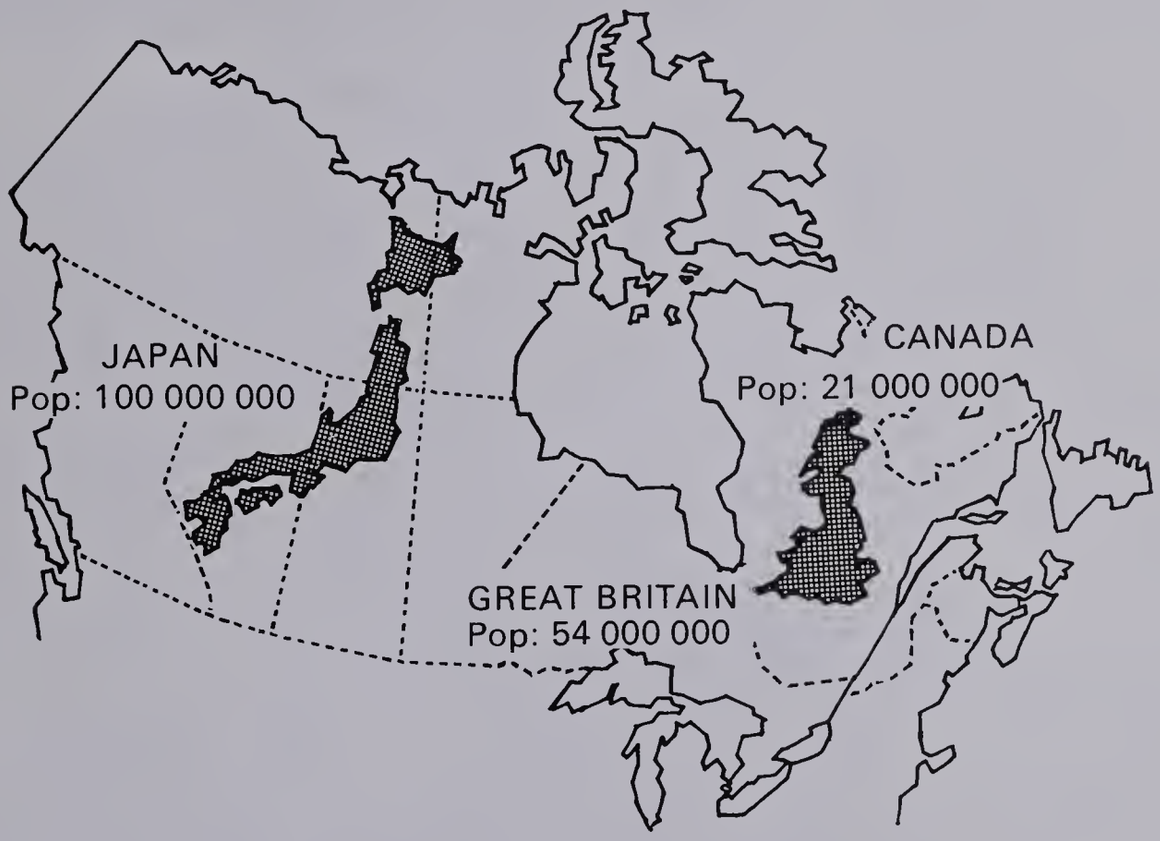
The soil that feeds us is continually being abused. This problem is so serious that there is an increasing struggle for food to feed the world.

The graph shows the speed at which the world's population is growing. From the time of Christ to 1650, the population in the world doubled. The next doubling occurred between 1650 and 1850, in only 200 years. The third doubling took 75 years and was completed in 1928, bringing the world's population to about 2 billion people. By 1960 there were 3 billion. If the present rate of increase continues, the 4 billion mark will be reached in 1977. Can you estimate when the fifth doubling will happen?



In Canada, only 7% of the land is at present suitable for agriculture. Much of this land is in the south, where the quickly-growing cities gobble up large quantities of farmland every year. Dr. E. G. Pleva, of the University of Western Ontario, estimates that by 1980, 30 000 000 people will live in the "Grand Trunk Corridor" which stretches 1120 km from Quebec City to Windsor. This compares to approximately 21 000 000 people in all of Canada in 1970. Yet Canada is very fortunate compared with many countries.

Why do these facts suggest the need for good soil care?



Discuss the part modern science plays in improving soil through the use of irrigation, crop management, grazing controls, and fertilizers.

Use the following statements and photographs to discuss the importance of soil.

A typical oasis in the Middle East.

The hoodoos of Alberta, are evidence of erosion. These lands are nearly dead. Why? Are more of these waste lands likely to develop? Should such deterioration be stopped? How might this be done?

This photograph, taken in Saskatchewan in 1921, shows how wind-blown sand can destroy a farm.

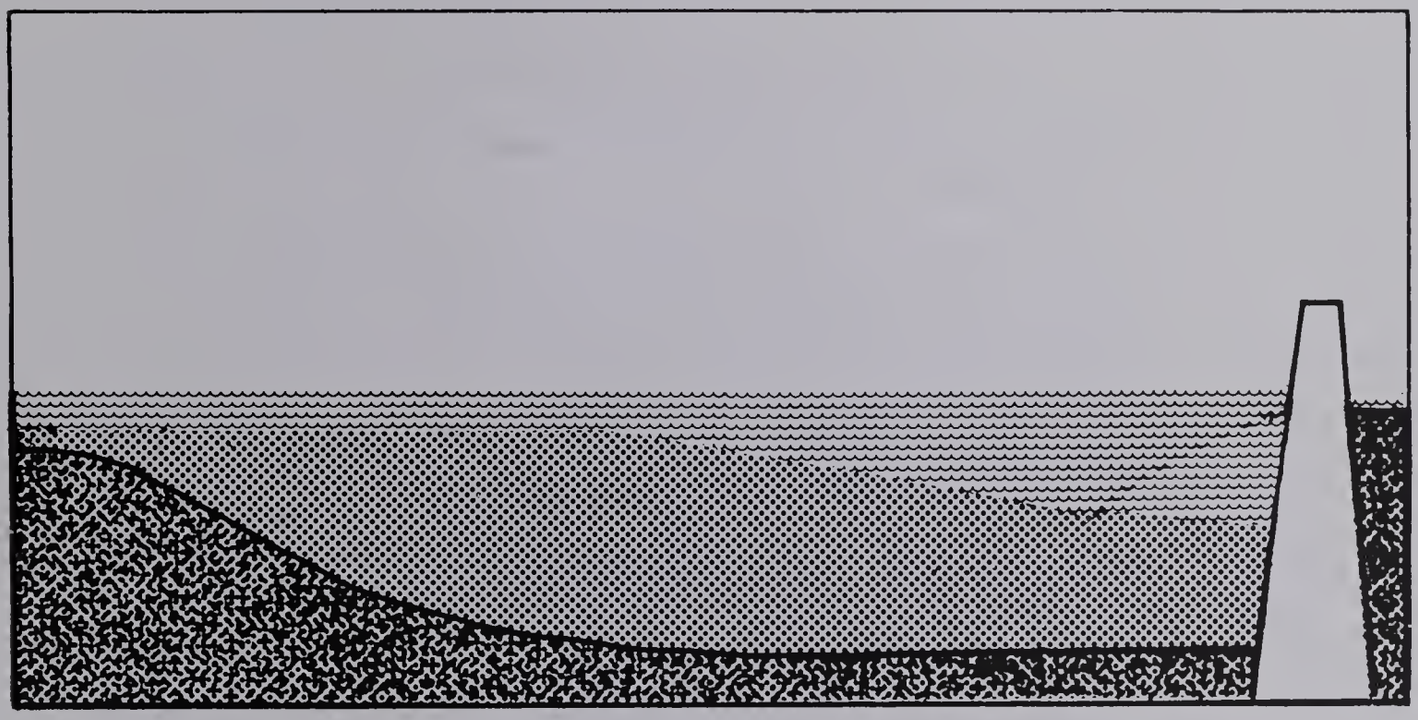
History tells of numerous cities, towns and farms destroyed by wind-blown sand. What can be done to prevent this erosion? Is there any evidence of wind erosion near where you live? Where is it most likely to occur? How can it be controlled? Other sections of this book will help you answer these questions.

Serious gully erosion of agricultural land means that much money will have to be spent to make the land useful again to the farmer.

THOUGHT-PROVOKERS

Workmen in Charlottetown, Prince Edward Island, recently had to dig through 21 m of topsoil to reach a solid foundation for bridge piers.

In 26 years, a powerhouse reservoir in Virginia, U.S.A., lost 80% of its water-holding capacity to eroded soil sediments.



A rainfall of 25 mm can remove 225 t of soil per hectare.

Soil erosion is a creeping death—fatal to plants and animals.

In 1941 there were 1 600 000 ha of abandoned farm land in Canada's west. That same area could have produced 2 270 000 m^3 of wheat had it been protected from the destructive forces of erosion. However, Canada grows much

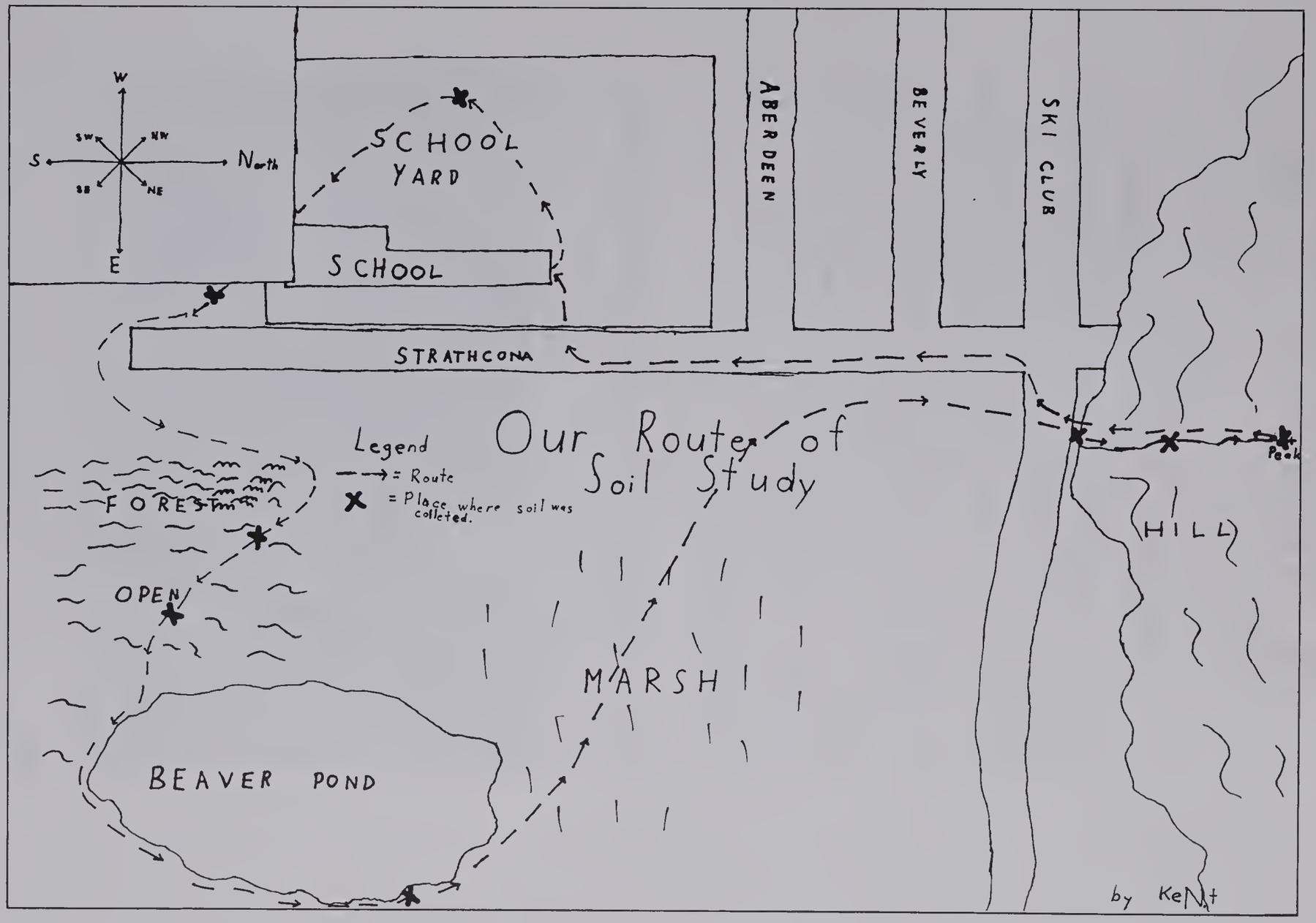
more wheat than it needs, and sells millions of cubic metres to other countries.

During one flood, the West Humber River in Ontario was estimated to have carried 2200 t of soil every hour.

In washed-out areas of the world, topsoil has become so precious that men have been known to steal handfuls at night to grow food for their families.

To Help Your Discussion

1. What do the above statements suggest about soil conservation?
2. What are some of the methods used in soil conservation? Discuss examples near your home. Do you know of any area where the soil needs to be conserved? What part can you play?
3. Look for examples of both good and poor use of soil. Describe these areas to your classmates.
4. With your classmates, make a map of your locality showing where there are examples of good and poor use of soil. Use this map as a guide for a field trip to observe local soil conditions. Compare your map to the one shown. It was made by an 11 year old pupil.


W
SW
NW
S
North
SE
NE
E
SCHOOL YARD
SCHOOL
ABERDEEN
BEVERLY
SKI CLUB
STRATHCONA
Our Route of Soil Study
Legend
= Route
= Place where soil was collected.
FOREST
OPEN
MARSH
BEAVER POND
HILL
by Kent

Chapter 2

INITIAL EXAMINATION OF SOIL

Activity 1: BEFORE GOING OUTDOORS

Discuss what you already know about soils. Use the following questions as possible guides.

1. What is soil?
2. What observations of soil samples can you make using your five senses (touch, taste, smell, sight, hearing)?
3. What differences would you expect to find in soil samples collected from such places as hilltops, valleys, swamps, beaches, stream beds, pond bottoms, open fields, roadsides, woodlands, near the surface, sub-surface, and so on?
4. Where may you go near your school or home to find different kinds of soil?

Activity 2: COLLECTING AND DESCRIBING SOIL

Collect as many different types of soil as can be found. Describe them in as many ways as possible. Do not search

Samples of soil were brought indoors for further study.

for names. Simply use your five senses to list familiar words that describe your findings. The book *Studies for Open Places* gives many suggestions for collecting samples.

After you have spent some time preparing descriptions, compare results with your teacher and classmates. Organize for further studies by doing the following.

1. List your different descriptions on charts or on the blackboard so that all class members can see them.
2. Group the descriptive words or phrases into meaningful sets.

Here are a few of the descriptions that were listed by one class. How do they compare with your observations?

damp, muddy, swampy-
like, powder, fine, crunchy,
sticky, moist, dirty, pieces of
grass, dry, smooth, nice, like
rotten wood, fishy, spongy,
sandpaper, like a bog, gritty,
crumbly, rough, grey, smudgy,
oily, slimy, plasticine, black,
chunky, cold, rocky, flat

The following headings were used by pupils when they grouped their descriptions. Compare these groupings to the ones you used. Do you think that these headings provide enough groups? Why?

SET A

SMELL	TASTE	TOUCH	SOUND	LOOK

SET B

COLOUR	SIZE	CONTENTS	WHERE FOUND

Activity 3:
FURTHER QUESTIONS AND PLANNING

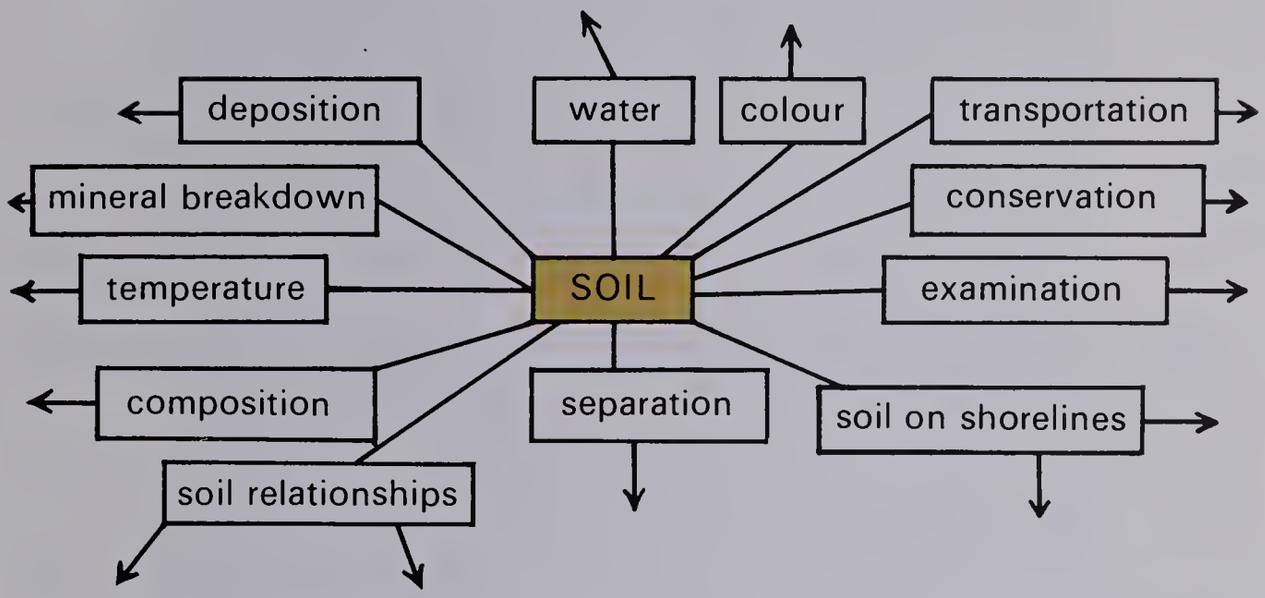
Think of all the things you have done with soil so far. Make a list of these. Arrange it so that you can make additions as you get other ideas from this book, from field trips and from other sources.

Think of questions that you want to have answered about soil. Keep these on a planning page for future reference. The following list was made by 10 year old pupils. Compare it with your list.

1. How is soil formed?
2. What are the uses of soil?
3. Is clay too fine to be called soil?
4. What is the best soil for growing plants?
5. Is all soil the same?
6. Does soil ever turn into rocks?
7. Do any animals eat soil?
8. What kind of soil is at the bottom of ponds?

These photographs show some of the things that pupils did during their initial examination. Compare them with your beginning activities.

See if you can get additional ideas from *Studies for Open Places*. It has a section about soil which starts on page 66. There are questions on pages 71, 72 and a chart on page 72. Do these give you more ideas? Try to expand the following chart. Some main branches have been started but no sub-branches have been added.



Is it now time for more careful planning? Study the following chart. Perhaps you would like to make your own planning form to guide your soil studies.

A CONTRACT TO STUDY SOIL

Patricia Russell (12) June 8-12

DAY 1 OK	decide what to study	look at books, filmstrips, for ideas · Talk with my group & teacher	library materials · notebook
DAY 2 good question / may need more than 5 days	What is soil composed of?	make list of all inquiries in good note book pick samples	hand lens · microscope · soil
DAY 3 need for more carefully kept records	How many live animals were in 2 kg of woodland soil?	Close examination woodland soil · Do berlese funnel exp.	berlese funnel same as day 2.
DAY 4 microscope life ?. water ?.	① to burn out humus · ② to find percentage air in soil	Try humus exp. at home, air at school. Finish plans	
DAY 5 - a good oral report / to continue		interview with teacher. report finds to group 4.	notes records problems

P. S. My teacher helped me make this contract.

Some children at this school found that many ideas from their soil studies could be expressed through creative movement. These 12 year old boys and girls found it most enjoyable to use their bodies to illustrate the effects of wind, water and ice on grains of sand. Some imagined they were soil particles, while others played the part of the destructive forces of erosion.

Chapter 3

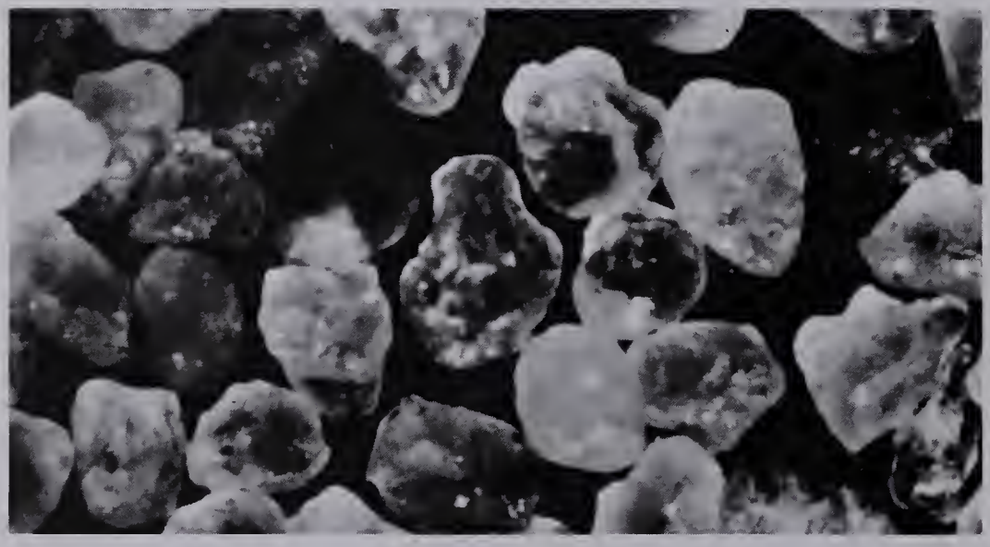
COMPOSITION OF SOIL

If you have worked through the earlier parts of this book you will be aware of some of the things that form soil. The activities in this section will help you to examine soil more carefully, and to become more familiar with its components.

Activity 1: A CLOSE LOOK AT SOIL

Examine two or three soil samples taken from different locations. Use only the naked eye. Look carefully for a few minutes and record all the different things you see.

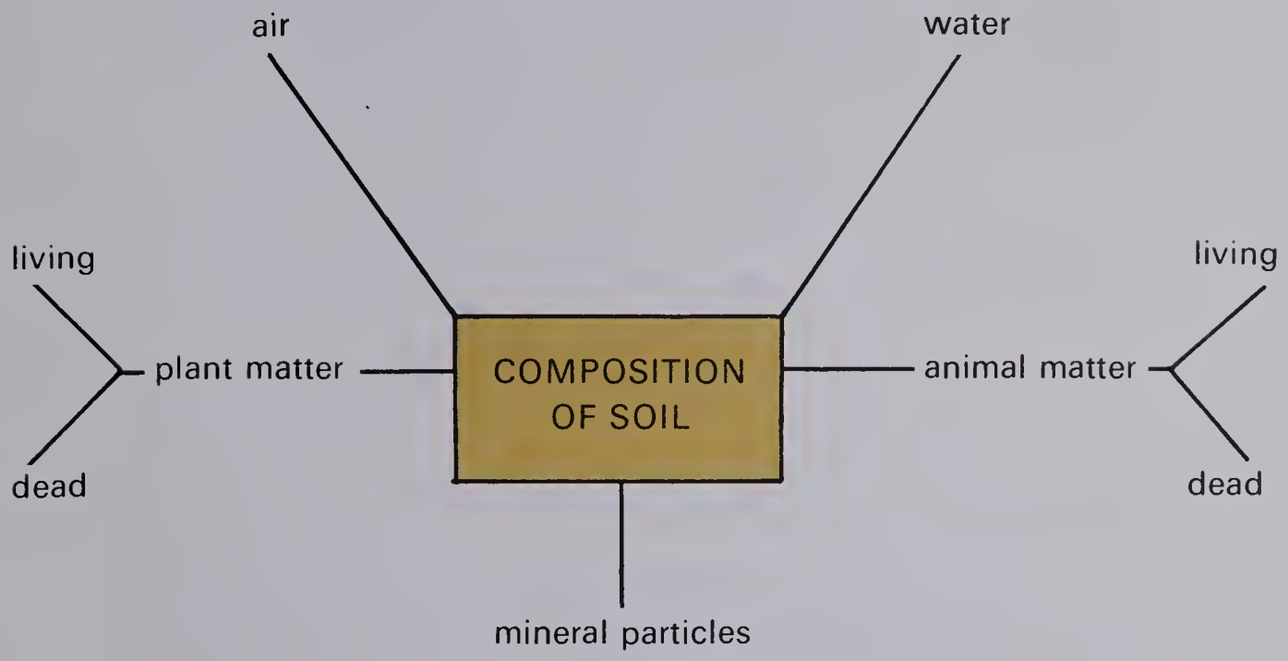
Look more closely at the same samples using a hand lens. This should magnify particles about 10X and will allow you to see things you did not notice before. Describe anything that looks different under the lens.



Magnification of typical beach sand.

Use a microscope to take an even closer look at the same samples. If possible, select different magnifications to find which is best for viewing soil samples. Prepare some permanent slides of specific shapes, and other things observed. If you need help in using the microscope, look at pages 75 to 79 of *Studies for Woodlands*.

The following chart shows some things usually found in soil. Did your sample contain evidence of these?

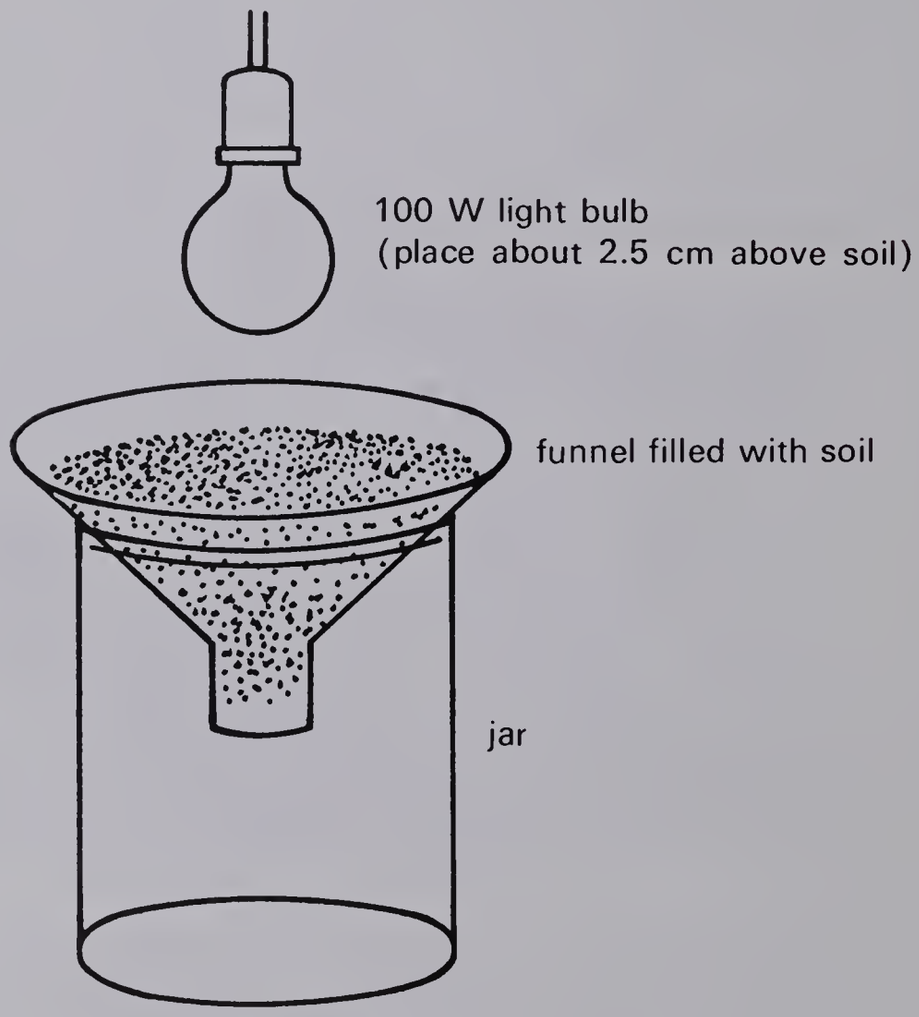


Minerals are naturally-occurring chemical elements or compounds. For example, Gold (Au) is an element, and salt (NaCl) is a compound. Rocks are composed of two or more minerals.

Do you think the spaces between the particles are part of the soil's composition? What types of plant and animal matter were there? Did you notice any signs of leaf parts, bones or animal tissue? What colours were evident in your samples? Was there any smell?

Activity 2:
SEPARATING SMALL LIVE ANIMALS FROM SOIL

For this activity, if possible collect a few kilograms of moist forest soil. If this is difficult, collect the sample from a garden or some place where there is active plant growth. Set up the equipment as shown and leave it for several hours. When you have finished, save the sample of soil for the next activity.



If it is necessary to kill the animals for further study, add some alcohol to the jar. Otherwise, they should be returned to the same kind of soil.

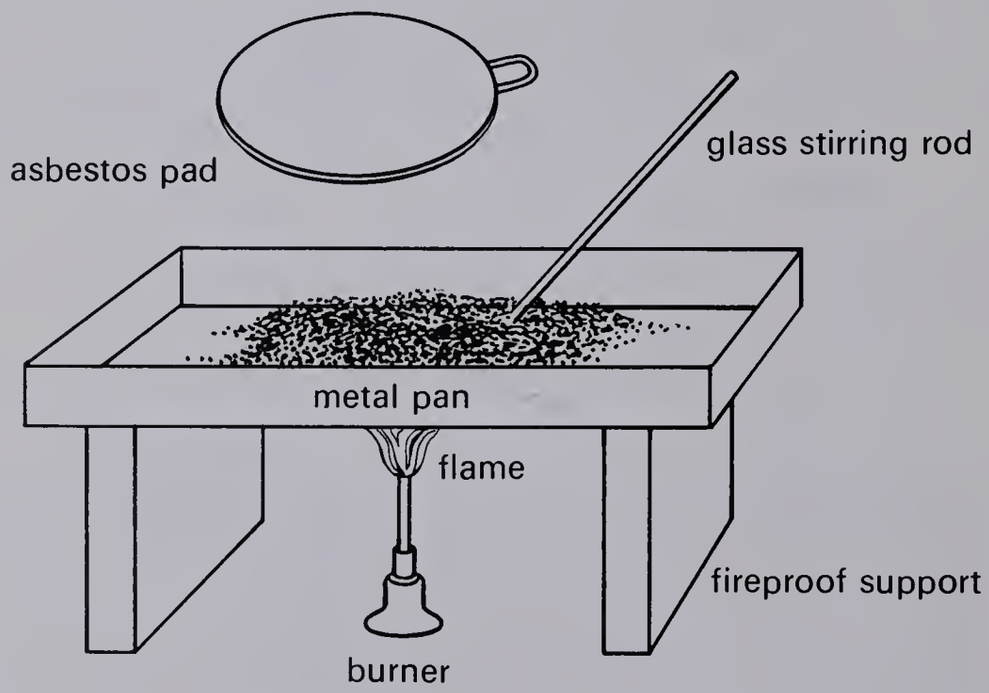
1. Predict what might happen in this activity.
2. Explain your observations.
3. What is the purpose of the light bulb?
4. Use sketches to record your findings.
5. Test samples of soil from different locations, for the presence of small live animals. What conditions seem to influence the numbers and kinds of such animals in soil? Use a chart to show this relationship.
6. List questions you want to research or discuss with other people. A sample list, already started, is shown below.

1. Why are earthworms only found in certain places?
2.
3.
4.
5.
6.

Activity 3:
REMOVING DEAD ANIMAL AND PLANT MATTER

For this activity, use the soil from Activity 2 with the live animals removed. Place the sample in a metal pan and heat intensely. Mix the soil using a glass stirring rod. This should help the humus (well-decomposed plant and animal matter) to burn off. Be careful when using a burner!

Why is this a useful piece of equipment?



Consider These

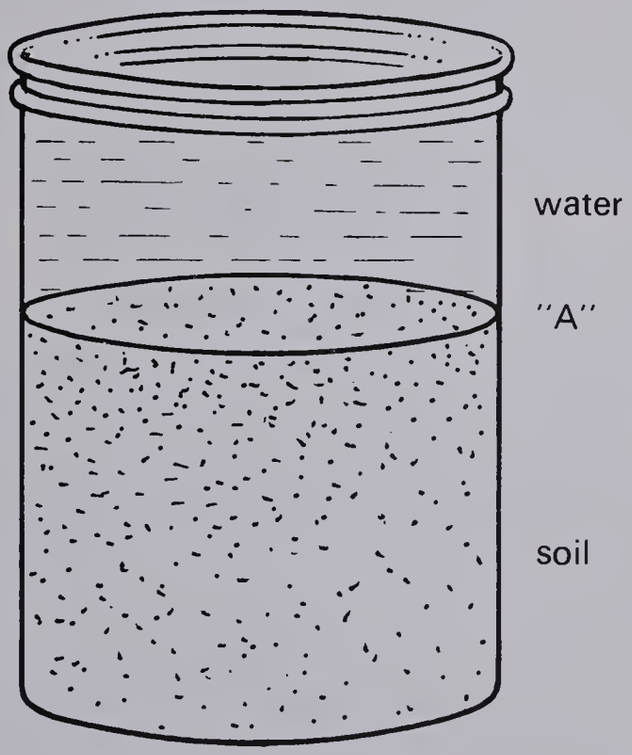
1. Describe changes that occurred in the soil as it was heated.
2. Use this activity to determine the percentage, by weight, of humus in a given soil sample. (Hint: two weighings are necessary.)
3. Do all soil samples contain the same amounts of humus? Make tests to check your predictions.
4. Do you think the heat also removed the water? How could you make a test to support your answer? If

water were removed, how would this affect your weight calculations in determining the percentage of humus present?

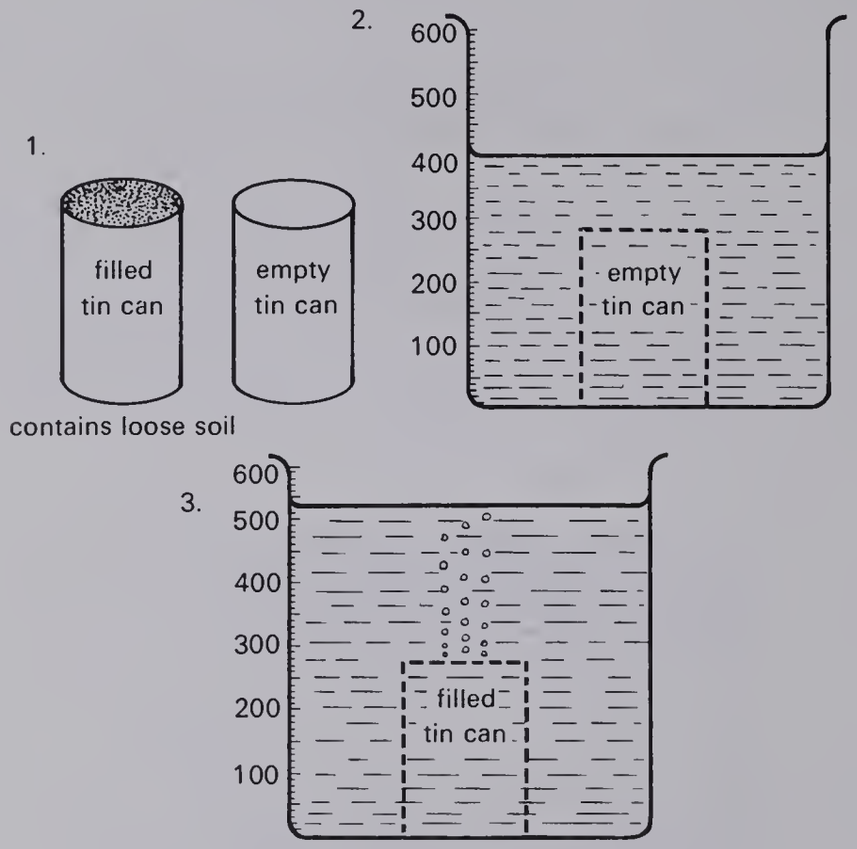
5. Place this burned-out sample in a sealed container, label it and save it for later experiments.

Activity 4: IS THERE AIR IN SOIL?

A test for air in soil can be made using the apparatus shown. Fill the jar with loose soil to level "A" and quickly add water until the jar is filled. What do you think will happen? Without adding any more water, carefully observe what occurs. Was this what you expected?



With the apparatus below, the volume of air in the sample is calculated by measuring the volume of water that is used to fill the spaces between the soil particles. Can you understand this activity before reading the detailed directions that follow the diagram?



1. Fill a tin can with loose soil so that the soil is level with the top.
2. Partly fill a graduated beaker (or another measuring container that you have made) with water, as shown in part 2 of the diagram.
3. Record the volume of the water.
4. Place an empty can of the same size as the one containing the soil into the water. Record the volume.
5. Remove the empty can. Place the can with soil in the beaker. Observe what happens to the water level (do not allow any to spill), and wait until the bubbles stop rising.

6. Poke a glass stirring rod or a piece of wire into the soil. Why?
7. Record the new water level and compare your findings with those below.
8. Use water to measure the holding capacity of the tin can. (Ignore any small loss of water that may occur.)

Calculations (a sample for comparison)

Volume of water in beaker	= 400 cm^3
Volume with empty can	= 415 cm^3
Volume occupied by empty can	= 15 cm^3
Volume of water held by empty can	= 120 cm^3
Volume of can and soil after bubbles stopped, as shown in part 3 of diagram	= 523 cm^3

Problem

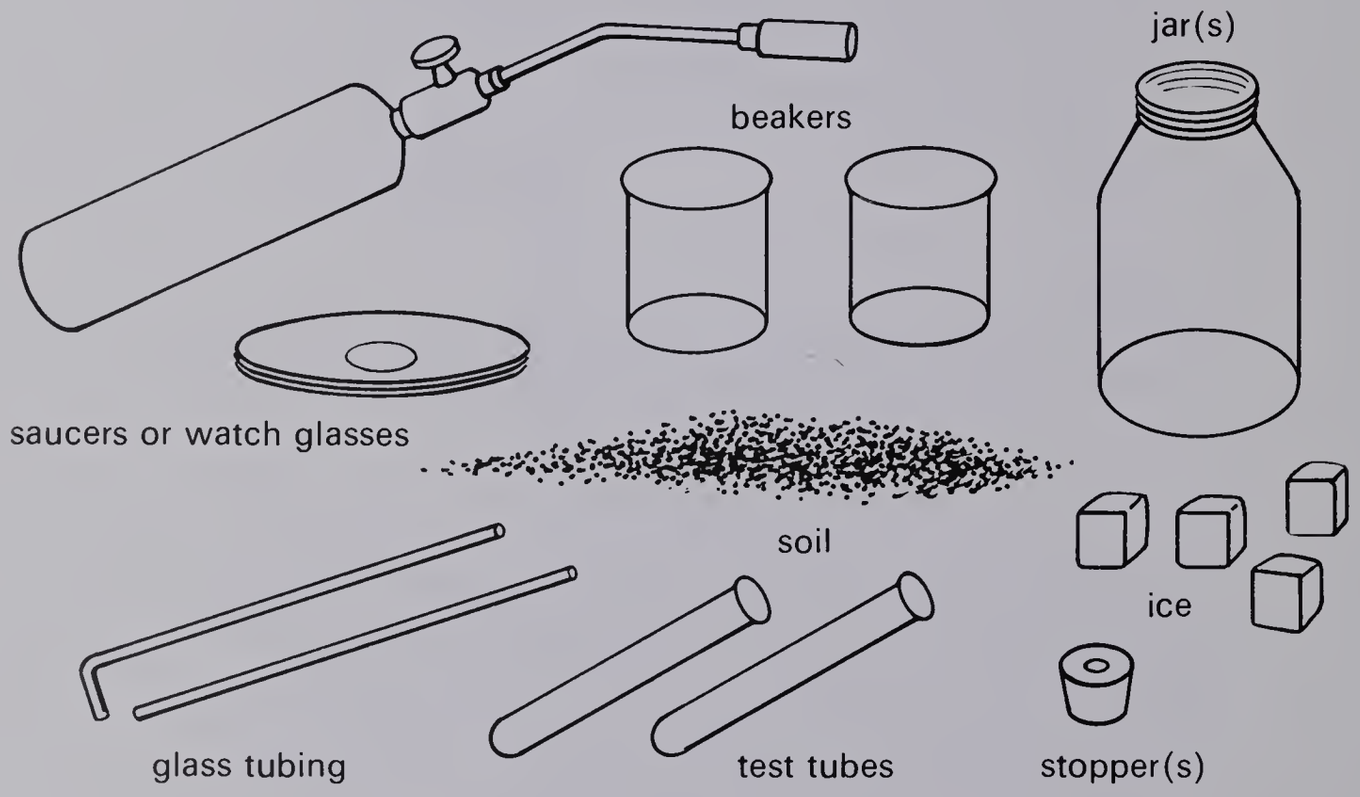
Calculate the percentage of air in the soil sample that was tested. Have someone check your answer.

Try This

Test various soils to compare their relative amounts of air. What factors appear to affect the amount of air in a given soil sample? Can you show a relationship between the percentage of air in a sample and some other condition, for instance, where you found the soil? Keep this problem in mind while you work with the next chapter.

Activity 5:
DOES SOIL CONTAIN WATER?

Sometimes it is easy to detect moisture in soil merely by feeling and squeezing the material (see page 99). At other times, however, this method may cause doubt because our sense of touch may not be good enough. Design a more scientific method to test soil for moisture. The materials in the diagram will give you some ideas.

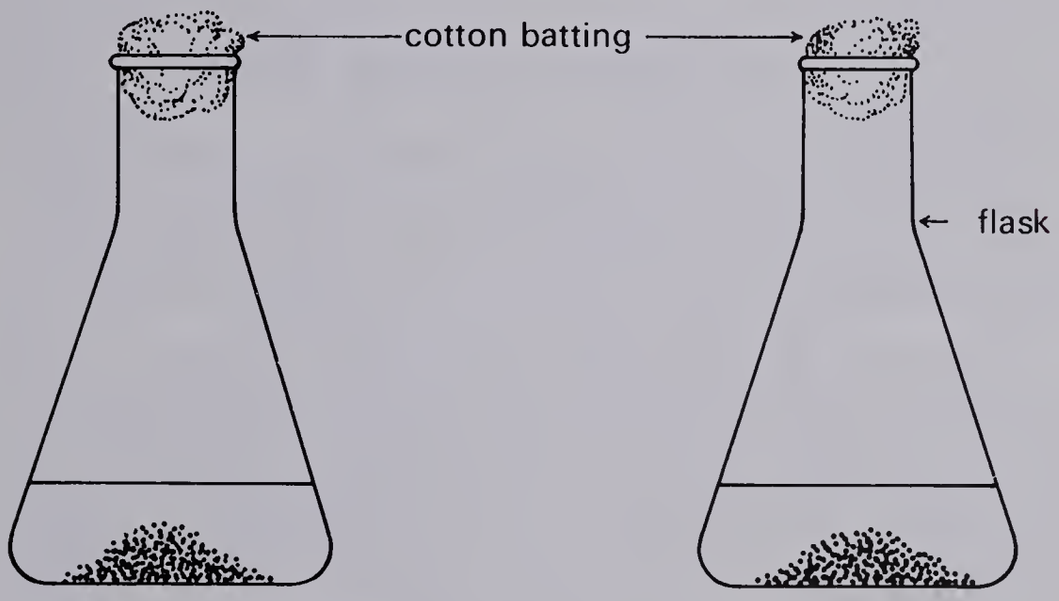


1. Explain your experiment.
2. Why is it unwise to draw conclusions from only one test?
3. How can you use a similar method to determine the proportion (part) of water in a certain soil sample? List the things you need to calculate the percentage of water (by weight) in a soil sample.

Activity 6:
MICROSCOPIC LIVING ORGANISMS

Activity 2 removed small animals (insects, worms, protozoa) from soil and Activity 3 took away humus (water also evaporated). This sample of soil, used to show the burning-off of humus, probably contained other living organisms that are so small that a fairly powerful microscope would be necessary to detect them. The following directions suggest a way to test for the presence of fungi, mold or bacteria that are usually present in soil.

1. Use a handful of the soil that was burned off in Activity 3.
2. Use an additional handful of unburned soil taken from the same location as that used in Activity 3.



"burned off" soil mixed with boiled milk

unchanged soil mixed with boiled milk

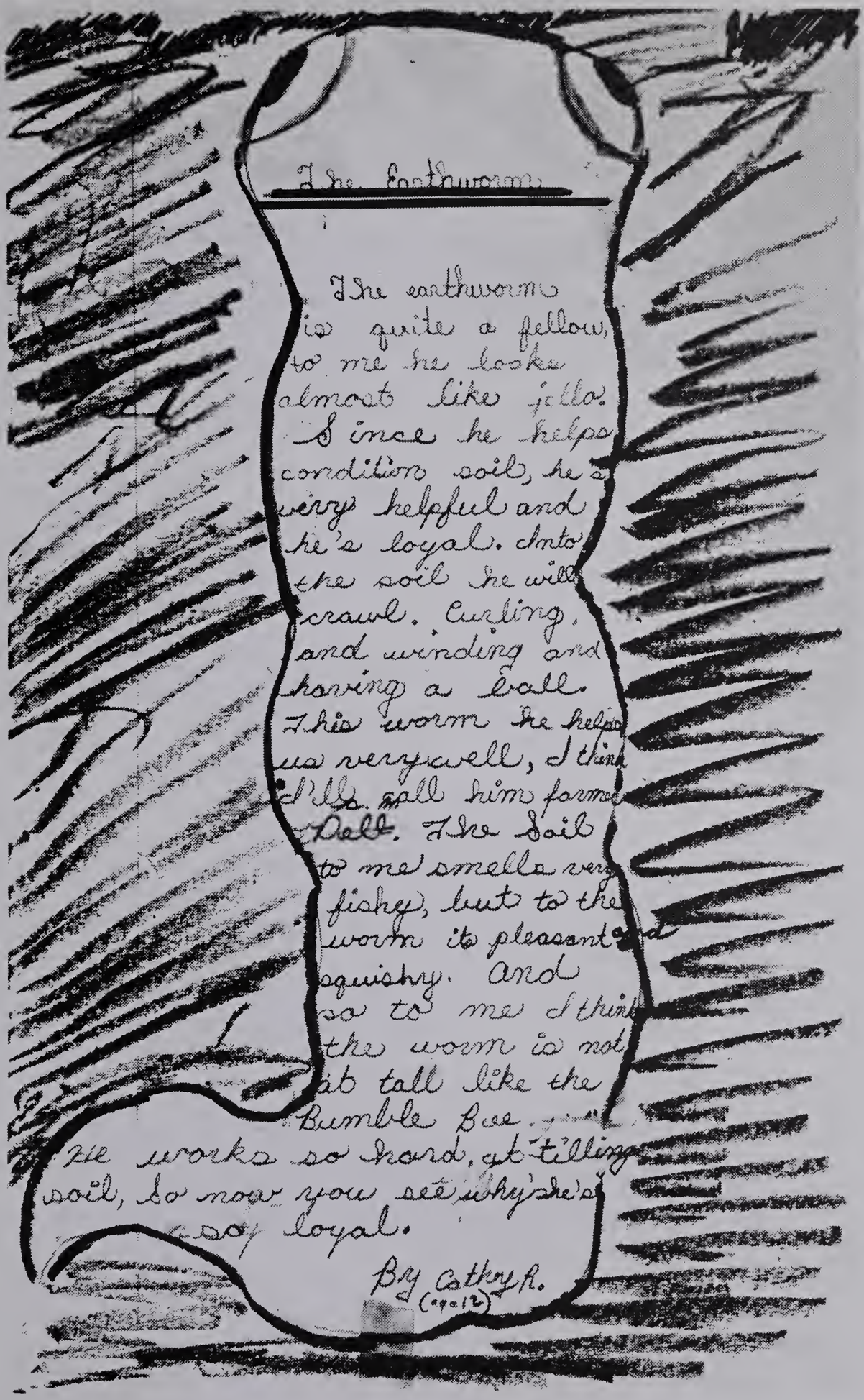
3. Place about 250 ml of milk in each of two flasks, close the openings with cotton batting and boil carefully for a few minutes. Allow the milk to cool and remove the cotton.

4. Place a handful of the burned soil in one flask and the same amount of the unchanged soil in the other. Replace the cotton.
5. Label the flasks and leave them in a warm place for about 24 h.
6. After the waiting period, remove the cotton stoppers and smell the contents of each flask. Explain.
7. Examine a drop of liquid from each flask with a microscope. One drop should show tiny creatures moving about. From which flask did the microscopic organisms come? Why were they not present in the other flask? Can these results be produced using soil samples from other locations? What general conclusions can you form?

Some Things to Think About

Now that you have removed plant material, animal matter and water from soil, only mineral particles are left. Place these particles in a sealed, labelled container, and save them for future use in activities in this book. In the meantime:

1. List the things you have learned about soil so far.
2. Are you continuing to add to the plans and questions that you started while doing Activity 3 of Chapter 2? (See page 25.)
3. What different ways have you used to record your findings?
4. How are you using what has been learned in other subjects to assist your soil studies?
5. Continue to compare and discuss your findings with others.
6. Are you mapping the areas from which samples have been taken?
7. What additional field trips are planned?



The Earthworm

The earthworm
is quite a fellow,
to me he looks
almost like jello.
Since he helps
condition soil, he's
very helpful and
he's loyal. Into
the soil he will
crawl. Curling,
and winding and
having a ball.
This worm he helps
us very well, I think
I'll call him farmer
Dell. The soil
to me smells very
fishy, but to the
worm its pleasant and
squishy. And
so to me I think
the worm is not
at tall like the
Bumble Bee.
He works so hard, at tilling
soil, so now you see why he's
so loyal.

By Cathy R.
(1912)

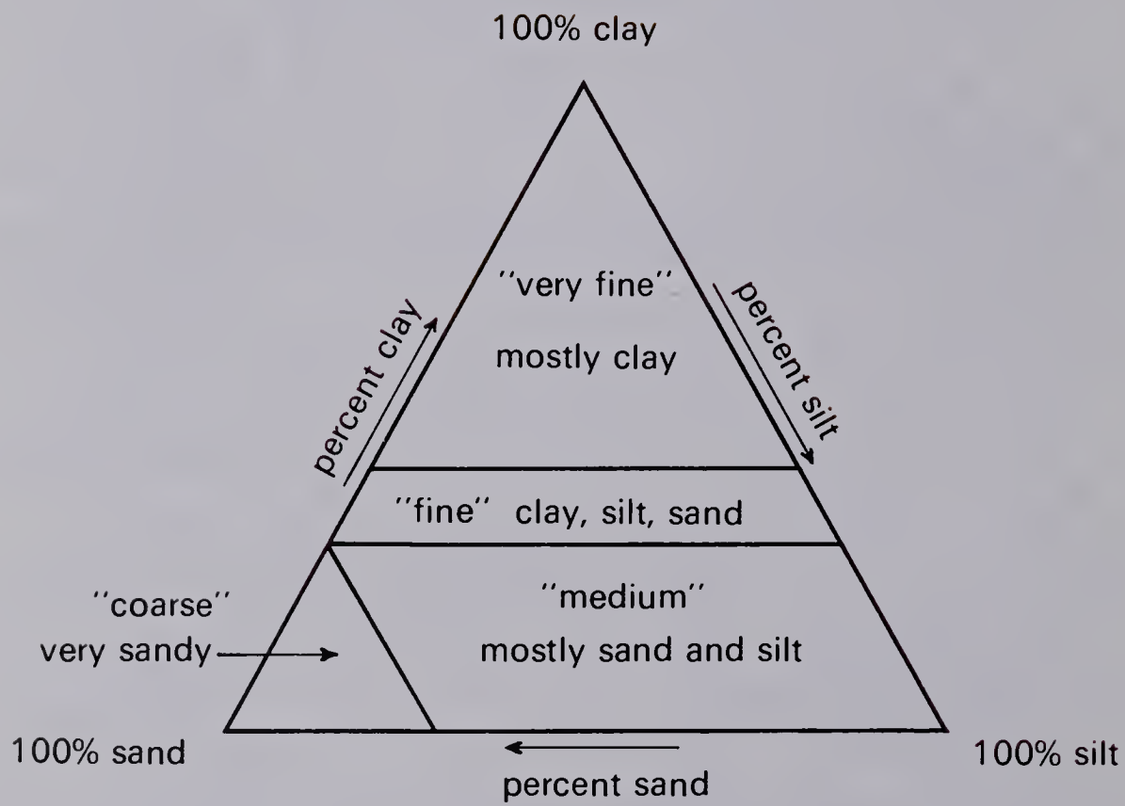
Chapter 4

TEXTURE OF SOIL

In this chapter we shall look closely at the texture of soil, in the same way that we examined composition.

Texture of soil is the proportion of particles of different sizes. A soil sample, for instance, might be described as being coarse, medium or fine texture. The following diagram shows a textural triangle. What does it mean?

TEXTURAL TRIANGLE



The names sand, silt and clay are determined by the size of soil particles. Which of these three names refers to the coarsest soil—which to the finest? Check the textural triangle to verify your answer.

Activity 1:
COMPARING TEXTURE

Examine a sample of soil. Classify it as coarse, medium or fine. Use the naked eye, or a hand lens, or a microscope if necessary. Other groups of pupils should name and record the texture in the same way. Then compare your classifications. Were they all the same? Why? Would it help to know the international scale for comparing the sizes of soil particles?

SIZE	NAME
more than 2 mm	gravel or stone
0.2 to 2.0 mm	coarse sand
0.02 to 0.2 mm	fine sand
0.002 to 0.02 mm	silt
less than 0.002 mm	clay

Your teacher can help you get an idea of each of the sizes mentioned above. It is also possible to buy screens that will sort soil into each of those sizes. Some scientific supply companies make sieve sets that will do the same thing. Some of these sieves are pictured on page 45.

Activity 2:
SOME THINGS TO THINK ABOUT

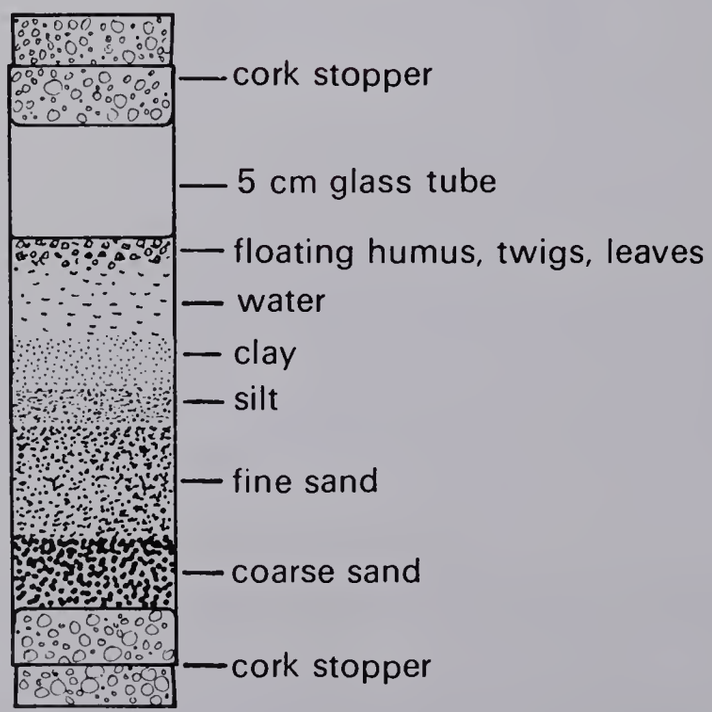
Texture has a big influence on the use, care and productivity of soil. Suggest ways in which the following might be affected by texture.

Tillage—how land is broken up.
Root penetration—how far roots grow down.
Water penetration—how far water soaks into the ground.
Water-holding capacity—how much water soil retains.
Nutrient-holding capacity—plant foods held by soil.
Aeration—the amount of air in soil.
Erosion—destructive forces acting on soil.
Drainage—dispersal of water on or under the ground.

Record your answers so that you may use them later. The following activities will help you understand more about texture.

Activity 3: SORTING SOIL WITH WATER

Soil can be sorted into particle sizes by shaking it with water and waiting for it to settle. The diagram suggests how this is done.

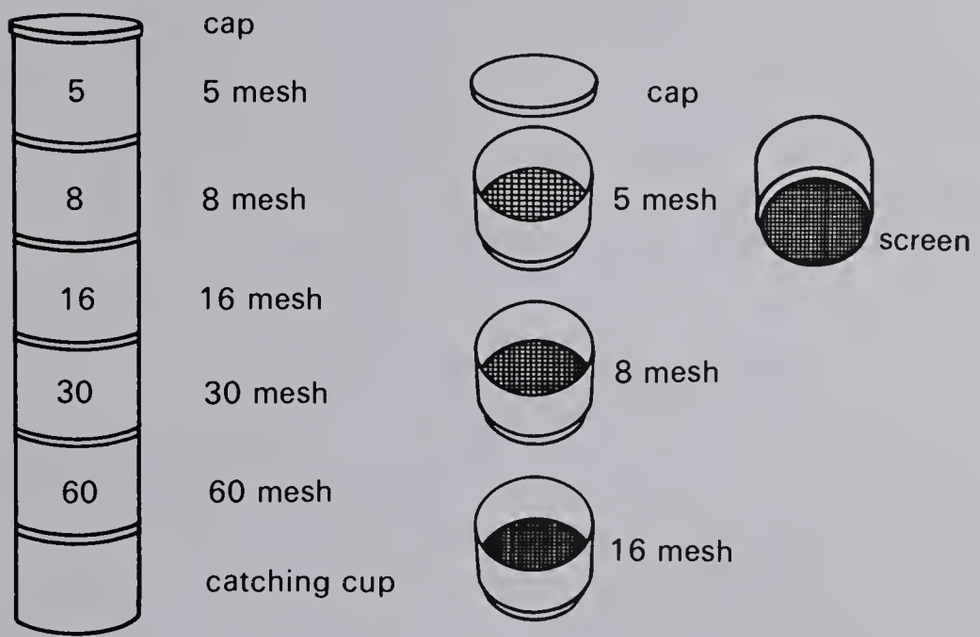


Activity 4:
SEPARATING SOIL WITH SIEVES

This activity has three purposes. (1) It allows a closer look at texture. (2) It shows how to compare texture of three different samples (beach sand, forest soil, gravel). (3) It prepares samples of different textures for further experiment. For this reason, keep different sizes in separate containers for future use.

Before beginning, decide how to weigh the particles. Would it be better to use a unit other than grams and to round off the numbers for easier calculation? Discuss these possibilities with your teacher.

A set of commercial sieves may be used.



Record the mass of each empty section. (Copy in your book the chart on page 46.) Put the sieves together, with the coarsest at the top and the finest at the bottom. The soil is sifted like this.

1. Half fill the top container with soil.
2. Replace the lid and shake the set of sieves. Hold the sieves tightly together at each end. Why?

3. Add more soil and shake again.
4. Continue these steps until there seems to be some soil in different sieves. You may have to shake some of the lower sections separately from those at the top.
5. Weigh each sieve with the soil inside. Record the combined masses as shown in the chart. A triple beam balance like the one on page 125 may be used.

BEACH SAND FROM TROUT LAKE

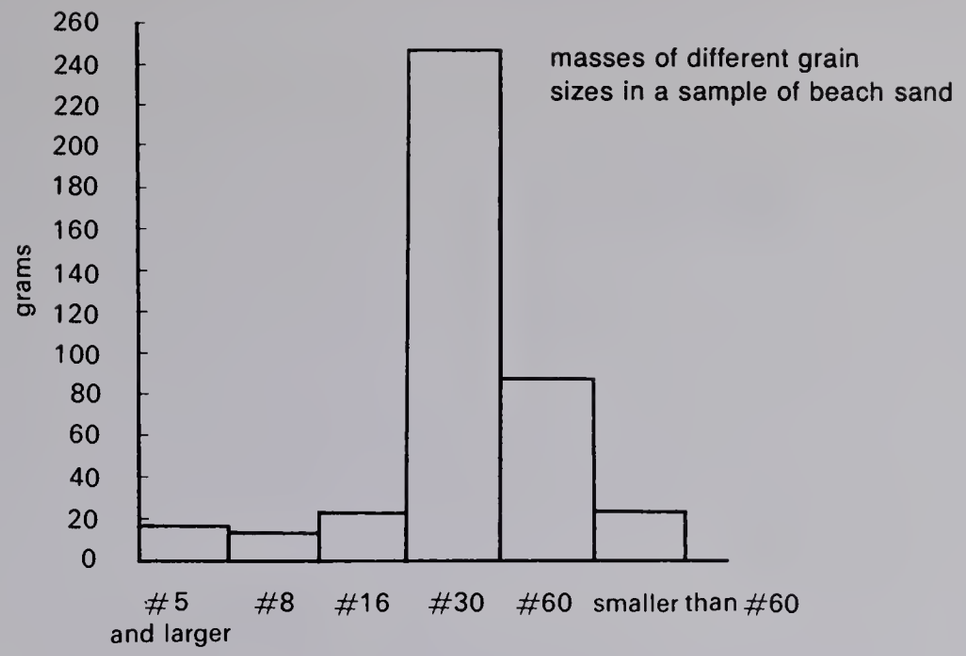
MESH SIZE	MASS (grams) (A) SOIL AND SIEVE	(B) EMPTY SIEVE	(C) SOIL (A − B = C)
5	85.2	70.0	15.2
8	82.8	68.5	14.3
16	74.4	51.3	23.1
30	321.0	74.3	246.7
60	160.0	73.0	87.0
catching cup	68.6	43.3	25.3
		TOTAL	411.6

Discussion of Findings

It is best to discuss the results of all your experiments. Research findings are only as good as the clearness with which you present them to other people. For this reason, it would be helpful to learn about good reporting methods in your English classes.

The above table is part of a report on the results of a beach sand sample. It is used to illustrate a method of reporting soil by grain size. The results show that more than half the sample went through the #16 mesh but was retained by the #30 mesh. In other words, 246.7 g of the sample were grains larger than the 30 mesh but smaller than the 16 mesh openings.

This chart illustrates a method of expressing the results.



Sometimes it is necessary to compare the distribution of grain size in different types of soil. Before this can be done, treat each mass as a ratio. Ask your mathematics teacher to explain why.

The following graphs show soil texture expressed as percentages. The beach sand sample already used is shown again. Calculations are included to help you transform the masses to percentages.

$$\text{percent} = \frac{\text{sample mass}}{\text{total mass}} \times 100$$

From the summary chart on page 46,

$$\#5 \text{ mesh: } \frac{\text{sample mass}}{\text{total mass}} = \frac{15.2 \text{ g}}{411.6 \text{ g}}$$

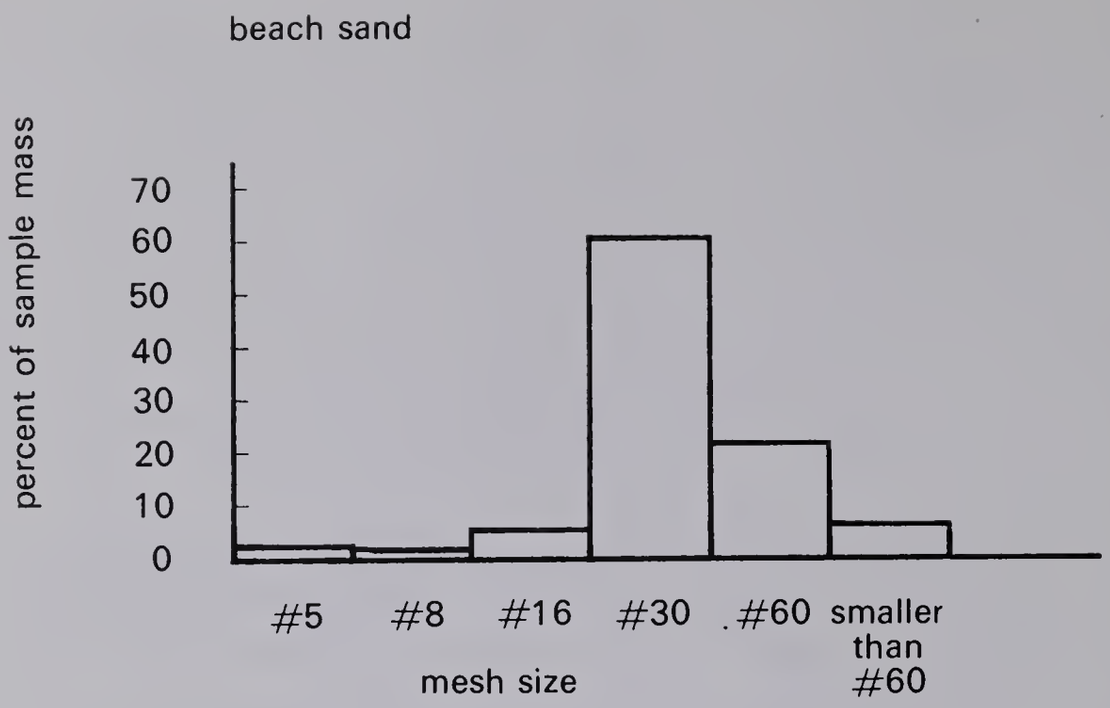
Therefore the sample mass is

$$\frac{15.2}{411.6} \times 100 = \text{percent of total mass}$$

$$\#5 = \frac{15.2}{411.6} \times 100 = 3.7\% \text{ (approximately).}$$

Similarly,

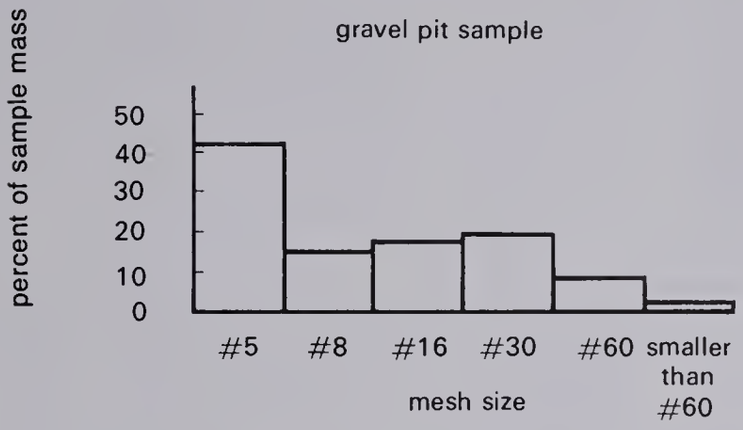
#8—14.3 g = 3.5% (approx.)
#16—23.1 g = 5.6% (approx.)
#30—246.7 g = 60.0% (approx.)
#60—87.0 g = 21.2% (approx.)
smaller—25.3 g = 6.2% (approx.)



SOIL SAMPLE FROM BIRCHHAVEN WOOD

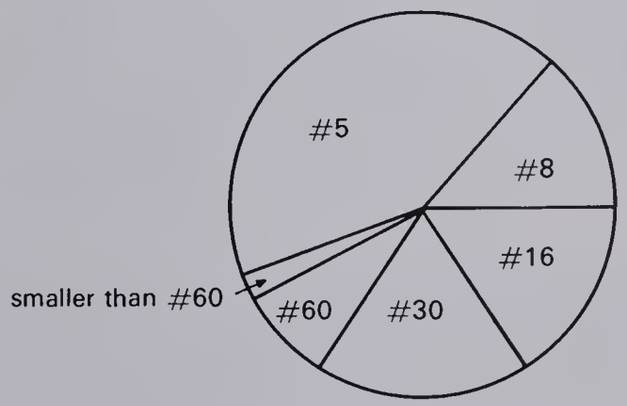
MESH	MASS (gram) SOIL AND SIEVE	EMPTY SIEVE	SOIL	SOIL BY % (APPROX.)
5	86.0	70.0	16.0	8.6
8	82.1	68.5	13.6	7.4
16	80.0	51.3	29.7	15.0
30	152.0	74.3	77.7	42.0
60	110.0	73.0	37.0	20.0
< 60	54.5	43.3	11.2	6.5
TOTAL			185.2	99.5*

*Can you suggest why the total percent was not 100?



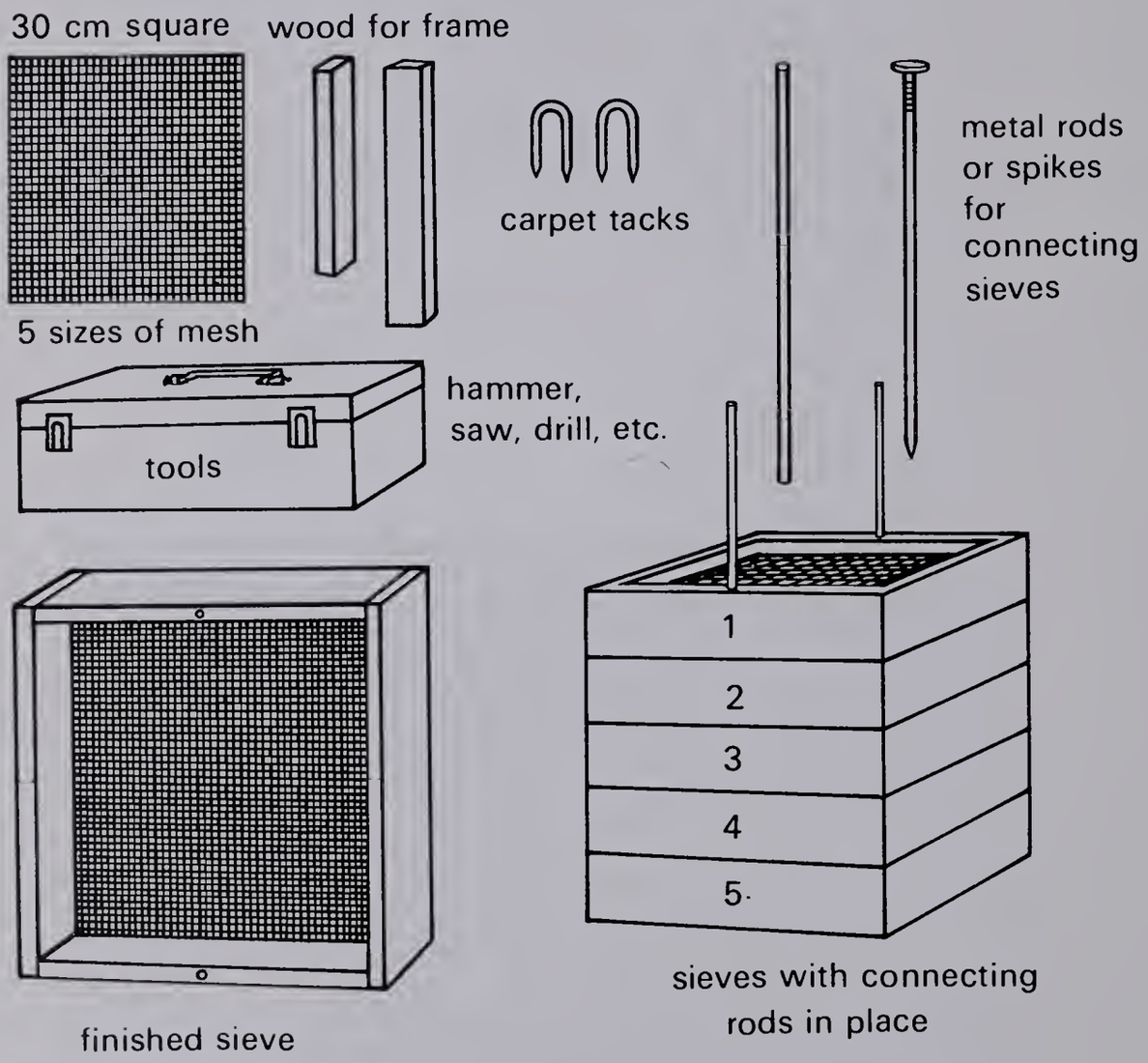
The three bar graphs compare the textures of beach sand, woodland soil and gravel. How could overlays be prepared to look at these comparisons with an overhead projector?

This same gravel pit sample is used in the following circle graph. Each section (sector) of the circle is the percentage of the total mass in the various sieves. How was the size of each sector determined?



1. Why were the masses of the various textures of each sample expressed as percentages?
2. Why is it necessary to use the same sieves when comparing beach sand, woodland soil and so on?

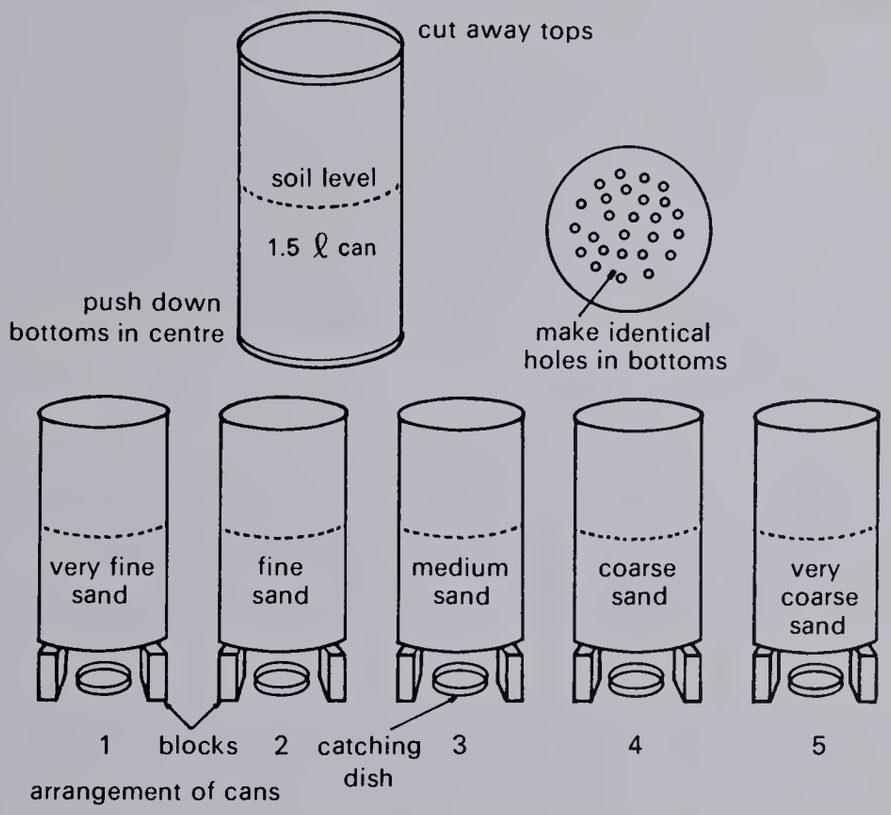
Home-made Sieve Sets



Activity 5:
TEXTURE AND WATER RELATIONSHIPS

After this activity you should have some indication of the way soil texture affects water penetration, water-holding capacity, and drainage. Who would find this information important? Why?

The following diagram will help you prepare the materials for this activity. Time will be saved if you use soil that has already been separated. If you are starting from the beginning, use beach sand. It is easy to sort and will be relatively free of humus.



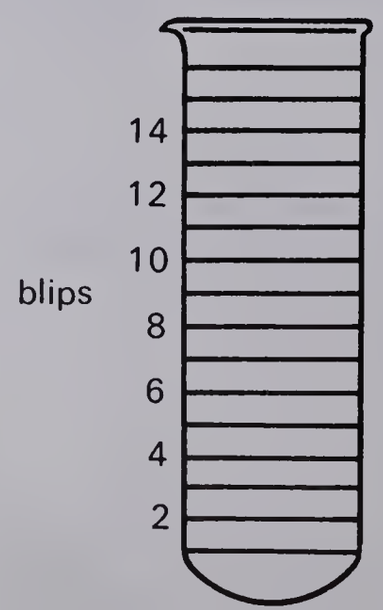
1. Place a piece of cheese cloth, filter paper, or similar material in the bottom of each can. Why?
2. Use the same mass of each of the five different textures of soil as shown.

3. Add an equal volume of water to each partly-filled can as near to the same time as possible. Note the time at which the water was added. Have a team work on these experiments.
4. Find a method to measure both the volume of water passing through each of the textures and the rate at which it moved. The following chart suggests a way to record your findings.

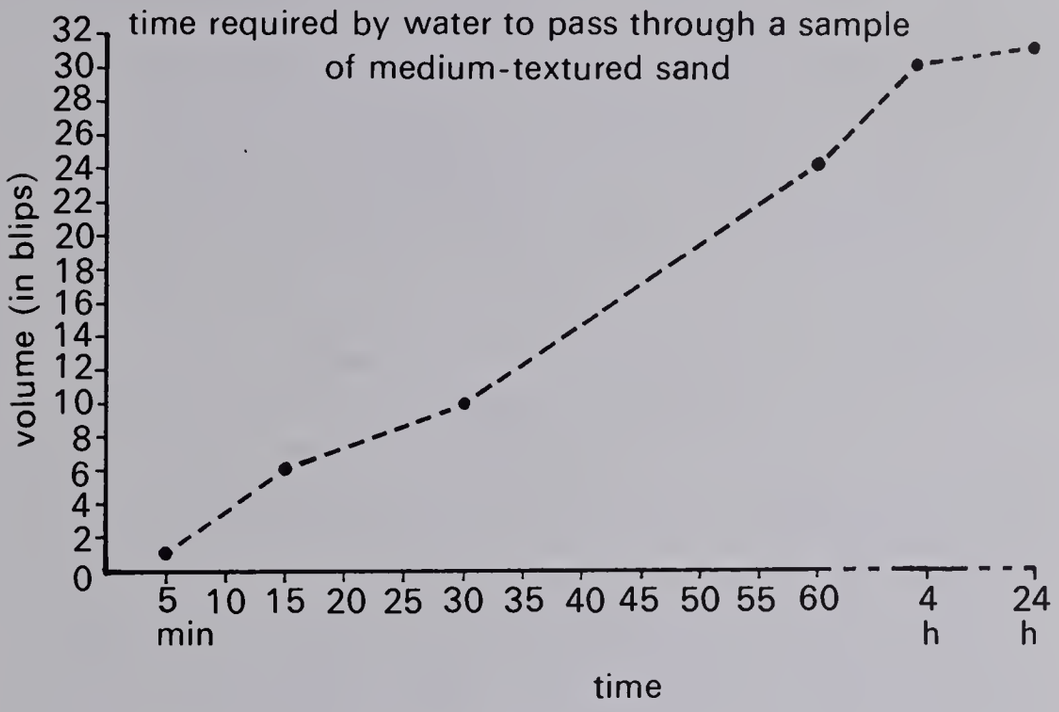
Time	very fine	fine	medium	coarse	very coarse
5 min.					
15 min					
30 min					
1 h					
4 h					
24 h					

Did you use standard units of volume such as cubic centimetres or did you develop your own standard for measurement? One pupil who tried this activity made his own graduated cylinder by marking equal volumes on a test tube. He chose the name "blip" to describe each unit.

How could he tell where to place each mark on the test tube?



This graph shows the results found when 40 blips of water were added to one of the cans. How much water was retained? What do you think the soil texture was in this case? Did you get a similar curve in one of your tests? Why are there breaks in the horizontal axis of the graph?



Other Things to Consider

1. Determine how texture affects the aeration of soil. Use your knowledge from this chapter and from Activity 4 of Chapter 3.
2. Do you think nutrient-holding capacity will be affected by texture? If so, how?
3. Save samples of soil that have been separated into different particle sizes. These will be useful for future activities.

Chapter 5

THE SKELETON OF SOIL

WHAT IS THE SKELETON OF SOIL?

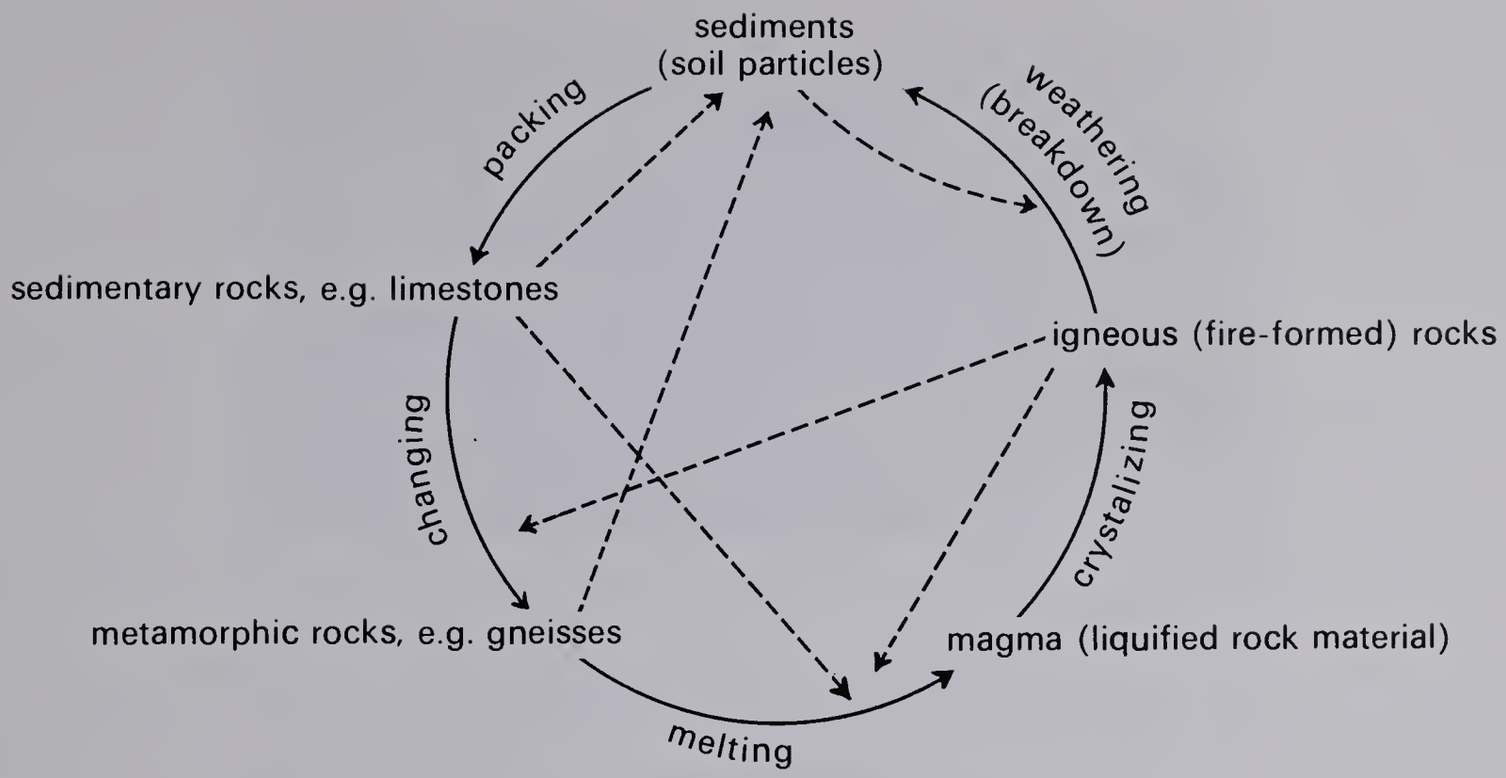
The word soil has different meanings for different people. The gardener, for instance, may say it is the top few centimetres where his crops are rooted. The civil engineer, on the other hand, may speak of the several metres of broken rock particles that cover solid bedrock. The soil scientist thinks of soil as being the unconsolidated (loose) mineral and organic material on the earth that is an essential factor for the growth of land plants. Let us say that the soil skeleton is mineral particles, possibly coated with organic materials, that are no more than 2 mm in size. If you need help with sizing particles, look back to page 43.

From your experiments in Chapter 3, you will remember that soil is made up of many things. About one-half of all soil is air and water. The remainder is mineral particles mixed with plant and animal matter. The activities of this chapter should help you learn about the "skeleton" of soil. This is the part composed of mineral particles. If you wish to make a more detailed study of soil's skeletal parts, refer to some of the books about rocks and minerals listed on pages 126 and 127.

The Rock Cycle

The production of rock is a continuing process that sometimes follows a circular path as shown in the following diagram. The process, or cycle, usually takes many thousands of years. While some particles are being produced, others are being carried, set down and packed to eventually form sedimentary (layered) rocks.

Crystals of quartz can often be seen when soil is looked at under a microscope. This is a well-formed crystal. Have you noticed similar shapes? What others are to be found?



Most rock-forming processes follow the outside solid lines starting from sediments. At the same time, however, other changes such as earthquakes may occur. These interruptions are shown by dotted lines in the diagram. The sediments sink from the surface of the earth until they are packed together. Continued pressure from above causes further sinking until the pressure and increased heat make the rocks change and eventually melt to form magma. This magma is eventually forced toward the surface again to be cooled and turned into igneous rocks.

The remaining activities of this chapter will help you learn how rocks are broken down (weathered) to form sediments. This breaking is only part of the rock cycle.

Weathering of rocks is caused by mechanical or chemical activity or both. Mechanical weathering is that process which breaks rocks into smaller parts without changing the rock's chemical makeup. Chemical weathering, however, causes a change that produces some new material. These actions are part of the soil-producing forces.

How is this volcano on North Island, New Zealand, helping to produce soil particles?

MECHANICAL WEATHERING

Activity 1: GRINDING ACTION OF ROCKS

Find two rocks that are soft enough to be marked by a knife blade or a nail. Hold them over a piece of paper and rub them together vigorously. Examine some of the powdery particles with a microscope. Sketch the different shapes that you notice.

Much of our soil has been produced by the grinding action of glaciers. Geologically as little as 15 000 years ago, much of Canada and the northern United States was covered by a glacier known as the Wisconsin ice sheet. This huge sheet, thicker than 1 km in places, pressed, gouged and scraped the earth's surface as it moved forward. When it retreated, millions of tonnes of broken rock debris were left behind. This debris is composed of clays and gravels called glacial till.

Evidence of water deposition from glaciers can be seen in the layered gravel of pit embankments. Glacial activity can also be seen in long parallel scratches on the surface of large flat rocks. Can you find any such signs in your locality?

Glacial striations on rock. (The lower photograph on page 89 shows another result of glaciers.) Below is the Athabaska Glacier in Jasper National Park. In the foreground are rocks dropped by the glacier as it retreated.

Activity 2: GRINDING ACTION OF SMALL PARTICLES

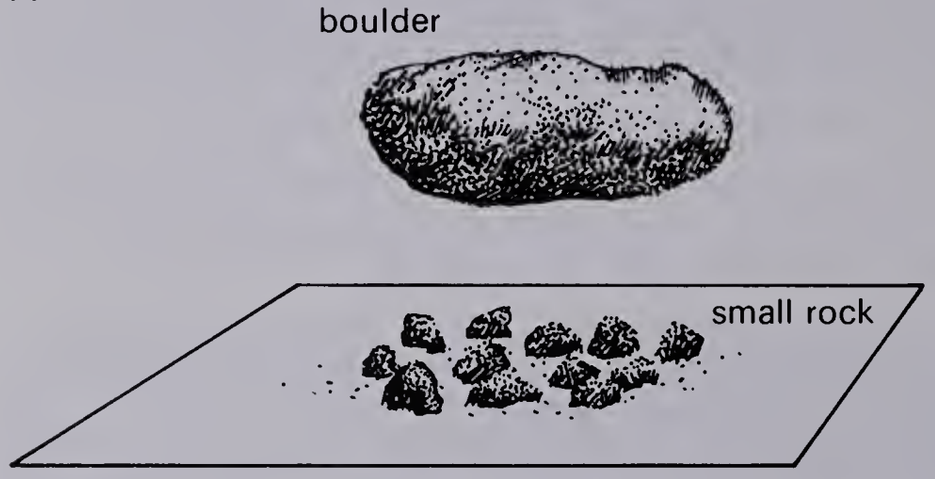
Attempt to grind small particles from a soft rock using sandpaper. Try a steel file. Which is better? Why?

Think of situations where this same type of grinding occurs in nature. (Hint: consider the carriers wind and water.)

Activity 3:
THE EFFECTS OF GRAVITY

Gravity is the force of attraction that causes a mass, when not supported, to fall. This same force plays a part in rock breakdown.

Place some small rocks on a hard flat surface and drop a boulder on them. Repeat the action several times. What happens?



How is the action shown above similar to what nature has caused to happen in the situation pictured below?

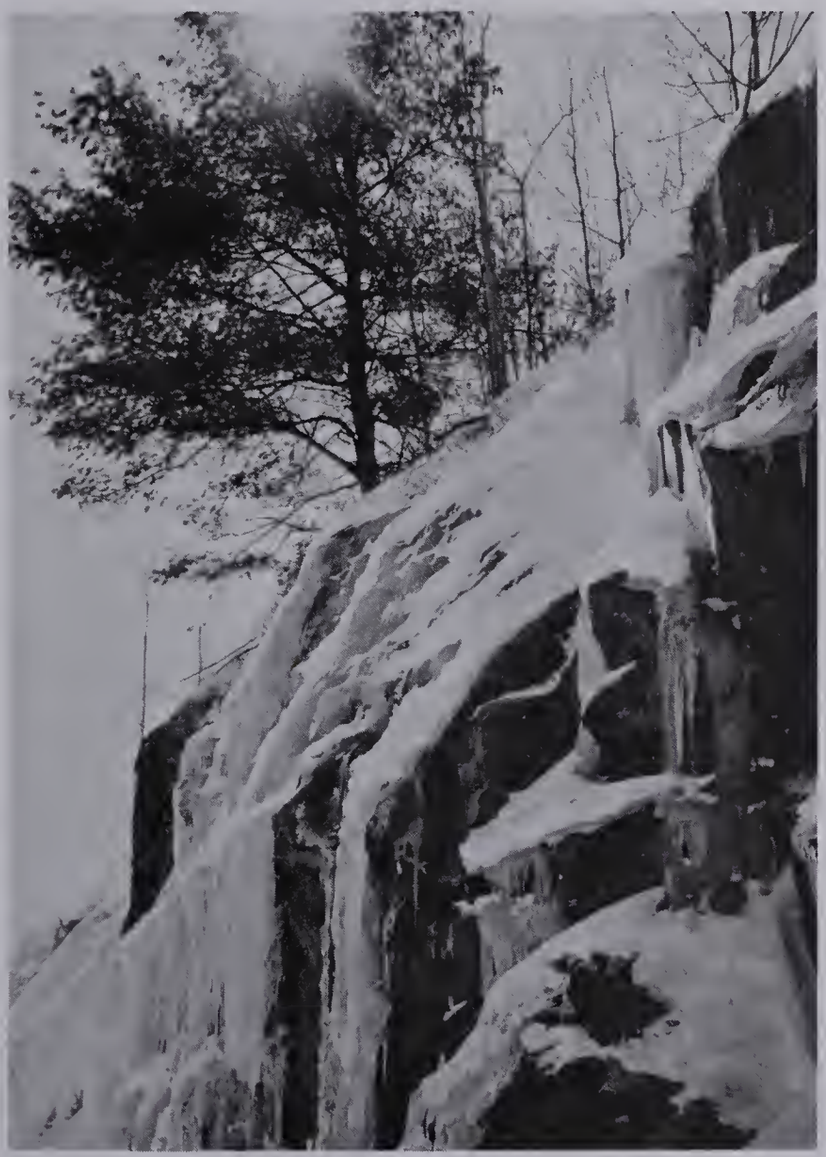
Describe other instances where gravity is acting to produce soil.

Activity 4:
CAN FREEZING WATER BREAK ROCKS?

Find a rock with many openings and cracks. Soak it in water for a few hours and then freeze it. Allow it to thaw and examine it for changes. Repeat the process, if necessary, until some change can be seen.

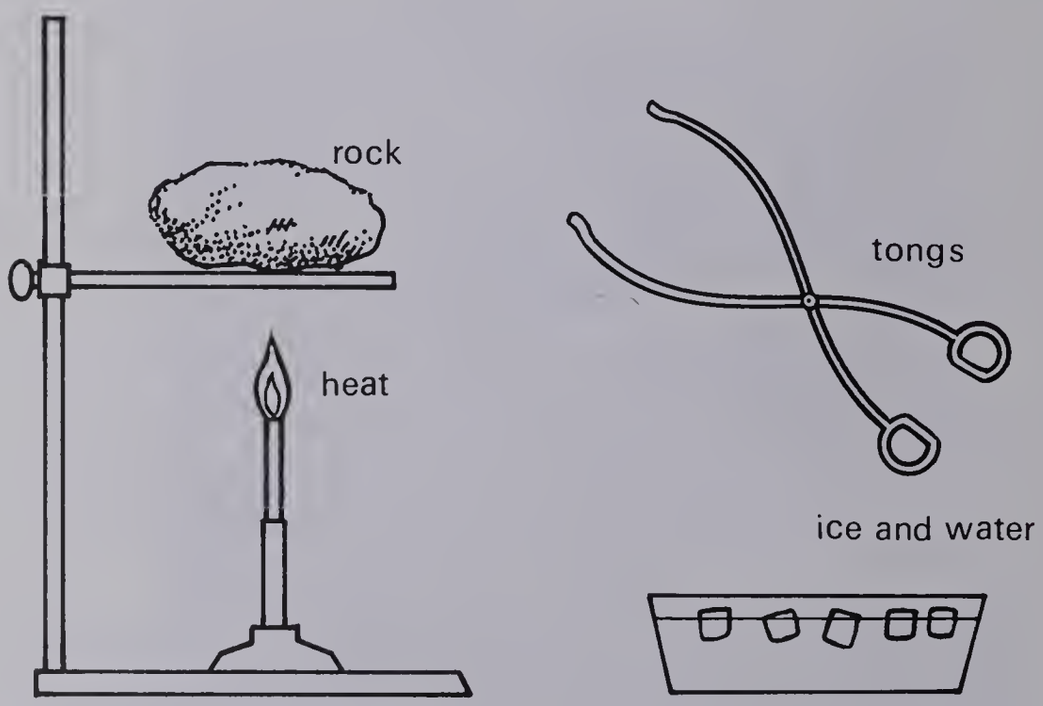
What is the effect of alternate freezing and thawing on wet rocks?

How are conditions in this photograph similar to those in the previous activity?



Activity 5:
HEATING AND COOLING AFFECTS ROCKS

Heat a rock intensely as shown in the following diagram. While it is still very hot, put it into ice water. Describe any changes. In terms of expansion and contraction, explain what happened? (Hint: This process may have to be repeated several times before results are noticeable. Best results will probably be obtained with a layered rock such as limestone.)



Look at the rocky land formation on the opposite page. As the trees continue to grow, how might the roots that are growing into the crevices affect the rock? How might the rock affect the plants? Try to find natural examples of this situation. Describe your findings and make predictions about possible outcomes.

CHEMICAL WEATHERING

Rocks are also broken down by chemical activity. When this occurs the rock material undergoes a change in its make-up.

Solution is one of the simplest examples of chemical weathering. Water may combine with carbon dioxide to form a weak acid solution. This, in turn, may attack certain rocks and dissolve parts of the solid material. This removal causes the rock to crumble. Sandstones and limestones are quite often weathered in this manner.

The photograph shows a limestone cut that is crumbly and soft as a result of chemical weathering.

Activity 6: EXAMINATION OF A USED TEAKETTLE

Examine the inside of a teakettle that has been used for some time. Did you find deposited rock-like material? How hard was the deposit?

The material that hardens in the bottom of kettles is a result of chemical weathering by solution which occurred long before the water boiled. Can you explain where the hardened material came from?

Activity 7: CHEMICAL WEATHERING

This activity will show the effect of one type of chemical weathering. It uses a strong acid to get results in a shorter time than would happen in nature. Because of the danger of burns from acid, this activity should be done under the close supervision of your teacher.

Place a piece of limestone in a glass beaker and cover it with a dilute solution of hydrochloric acid (HCl). Observe the reaction that takes place. Wait until it seems to be complete. Without letting the rock touch your skin, remove it from the solution and rinse it thoroughly under running water. Examine the rock for changes. Discuss these changes.

Chemical weathering has been mentioned only briefly so you will realize that it exists. An understanding of this type of weathering requires knowledge of general chemistry.

COMBINED WEATHERING

Mechanical and chemical weathering sometimes combine to break down rocks. When this happens, plants and animals usually play a part.

Amimals burrow into the soil; and allow air and water

to enter. As a result, these compounds enter into chemical reactions with underground particles to cause further breakdown.

Plants produce carbon dioxide by breathing and decaying. In addition, their roots make weak acid solutions. Both of these assist in the chemical weathering of rocks.

Bacteria may help weathering of rocks in two ways. First in aiding plant decay, they help to make carbon dioxide (CO_2). The carbon dioxide produced during this action may combine with water to form an acid that can directly attack rocks. Second, some bacteria increase soil fertility, thus aiding plant growth.

CLAY

Clay is the name common to various earths, and compounds of silica and alumina. Clay is earth which is stiff stickyand workable when wet. Many kinds of clay are used in the arts for pottery and modelling. Some homes are constructed with clay.

Research by Trudy Kirkbride.
age nine.

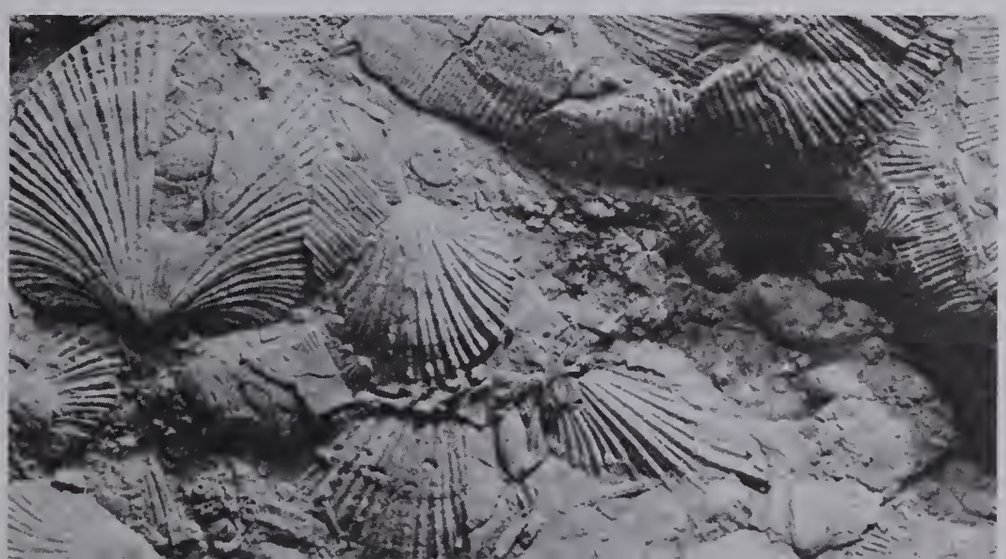
DO YOU HAVE A HOBBY?

If you have followed the activities of this book you will now see that the study of soil cannot be complete without mentioning rocks. As we look at these, many interesting questions arise. Why are there so many different colours? What caused the shapes? From where did the animal-like patterns in some rocks come? Why are some rocks softer than others? How can we tell when rocks contain valuable minerals?

Questions such as these have led to many hobbies. Sometimes, hobbies have even led to lifelong work. Perhaps this book will lead you to interesting activities that will provide hours of enjoyment. Here are some suggestions.

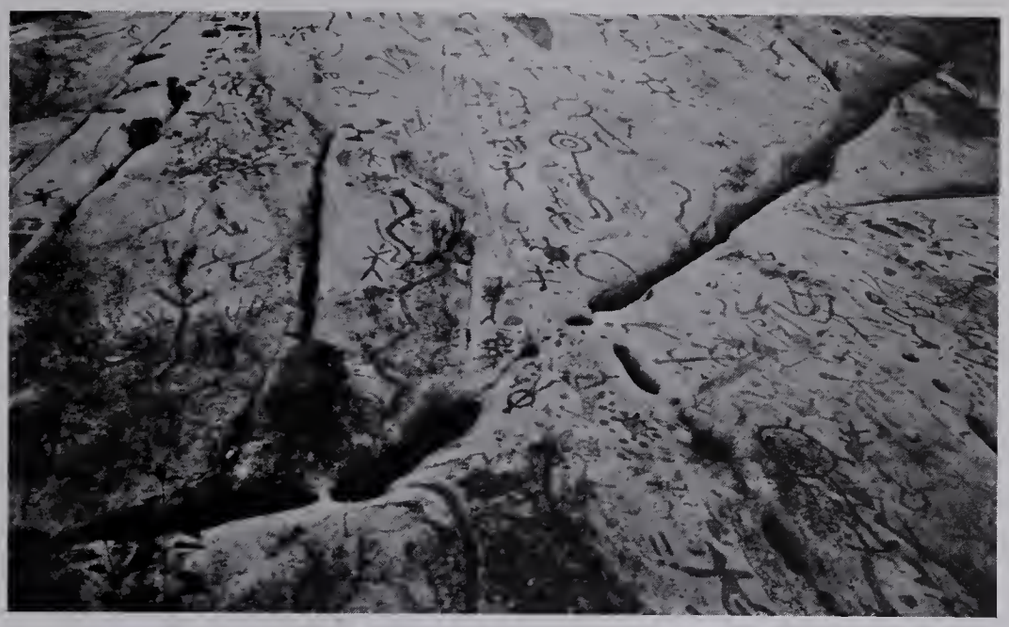
Rock and mineral collecting is a popular hobby. It is one of the fastest-growing leisure activities in North America. If you are interested, here is some useful equipment: a field guide to rocks and minerals, safety glasses, a geologist's hammer, cold chisel, magnifying glass, compass, heavy gloves, notebook and pencil, old newspapers (for wrapping specimens)—and a bag in which to carry everything.

Fossil collecting, as a hobby, appears to have been started by "rock hounds". Remains of earlier plants and animals tell a story of life on earth as it was millions of years ago. They have been preserved in many ways: in ice fields, tar pits, amber, and in sand dunes. The best preservative, however, has been sedimentary rocks. Limestone, such as is shown in the photograph of a quarry on page 62, is an ideal source for collecting fossils. The following photograph is of brachiopods, which you may be able to find. You will likely find many others as well.



The head of a pig-like mammal, Archaeotherium, is shown here being carefully removed from sandstone (a sedimentary rock) in Cyprus Hills, Saskatchewan. The photograph below is of the head as it appears now. The bone is the same as it was millions of years ago, but rock has crystallized in the small spaces in the bone. This process makes many fossils look and feel like rock.

This photograph may suggest another type of interest.



Many people are becoming more and more interested in local history. The history of the Peterborough, Ontario, area where the above photograph of Indian carvings was taken, is well known since the coming of the white man. Before that time, however, there are many gaps and questions. Perhaps carvings such as these can tell us much about the past. Someone must interpret them.

The Peterborough petroglyphs were discovered in the early 1950's by prospectors. There are about 200 figures from 15 cm to 1.5 m tall. They include symbols to represent humans, snakes, turtles and boats. Some are slight impressions in the crystalline limestone, while others are grooved to a depth of 4 cm. Their exact history is not known. They were probably made by Algonkians between 1000 and 1500 A.D., but no one has found definite proof. Was this a meeting place — a sacred ground? Why is there no supporting evidence nearby?

The Peterborough petroglyphs are an example of one of the many clues to Canada's history that lie waiting to be interpreted. Are there any similar clues near where you live? Do you think local history would be an interesting hobby?

Chapter 6

SOIL IN WINTER

DOES SOIL CHANGE DURING WINTER?

Many of the activities in this book are easily explored during fine weather when soil samples are easy to collect. However, we must not forget to consider soil conditions when the ground may be frozen and covered with snow. The following activities have been planned for the colder months of the year. They should help you answer the question which is the title of this section.

Activity 1: COLD WEATHER AND SOIL

Observe patches of bare ground as winter approaches. Explain what happens to the soil as the temperature drops below freezing. What changes occur in the appearance of the ground when the temperatures cause alternate thawing and freezing?

Does the hardening of soil depend on temperature only? Some of the following activities may help you to answer the question.

Activity 2: ESTIMATING THE DEPTH OF FROZEN SOIL

Once the surface soil appears to be frozen, measure the rate at which the "frost" penetrates the ground. This may be done by taking periodic (e.g. daily, weekly) readings as described below.

Find an iron rod about 1.5 cm to 2.5 cm in diameter by 1 m long. Use a heavy hammer to drive it into the frozen ground. It will be much easier to drive in the rod when it reaches the unfrozen soil. As soon as you realize you have reached the softer soil, mark the rod at ground level. Take it from the soil and measure the depth of frost penetration. Do this several times. An average depth will be more accurate.

Record all your data for future comparisons. Make some generalizations about frost in the soil.

Things to Think About

1. How might rocks hinder testing for the depth of frost?
2. Does changing the location by a mile have any effect on the depth of frost?
3. Find someone working on winter excavations who could tell you the depth of frost in your area.
4. How do workers who put sand on icy roads keep the material from freezing and forming solid blocks?
5. What effect does ground frost have on highways?
6. Try to find a pen pal in a more northerly and/or southerly school who would be interested in sharing experimental data about frost depths.
7. Why is it important for some people to know about the depth of frost in soil?
8. See how many things you can find out about permafrost.

These thick layers of ice in permafrost were found near the Mackenzie River delta in the Northwest Territories.

Activity 3:
DOES SNOW INSULATE SOIL?

This activity, to be explored outdoors on a very cold day after the snow comes, will need at least two thermometers. These should be selected in pairs so that they will give identical readings when measuring the same temperature conditions. (You will soon see why accurate thermometers are needed.)

Scrape a patch of ground clear of snow and lay one thermometer on the cleared space. Leave it for about one hour. Put the other thermometer on a nearby patch of ground but cover it with 50 cm of loose snow. Why is it better to leave the snow loose than to pack it?

After an hour, record the temperatures registered by each thermometer. Explain your observations. Was this what you expected to find?

If enough thermometers are available, work in pairs to get several comparisons. This data could then be grouped to obtain more accurate estimates of snow's insulating effect. How will an early heavy snowfall affect the depth of frost penetration in soil?

Even the roads are wrapped up against the cold these days. The white sheets being laid on this road foundation are styrofoam. This helps to prevent "heaving" of road surfaces by reducing frost and water penetration.

WARM IN THE SNOW

Have you heard how the ruffed grouse takes shelter from the severe cold of mid-winter by burying itself in snow? Snow, especially new-fallen, fluffy stuff, has excellent insulating qualities that this bird has learned to take advantage of on sub-zero nights.

While snowshoeing in the woods on a cold afternoon last January, I almost stepped on a grouse hidden in the snow.

The grouse had settled in sometime between 13:00 when I first crossed the little treeless knoll, and 14:00 when I returned that way. I didn't notice the fresh 2 m long furrow with its sharply curved end until I was almost upon it, and before I had time to realize what it was, my left snowshoe was settling into the loose snow hiding the bird. It burst into sight with a roar of wings and a cloud of powder snow like a miniature rocket blasting off, giving me quite a start.

After a fresh snowfall, as in this case, the grouse literally dives into the snow. If the surface is firm, it lands and walks to the chosen site, usually in a small clearing, and burrows out of sight in a cavity beneath an insulating layer of undisturbed snow a foot or so beyond where its trail disappears. If the snow is heavily crusted the bird is forced to roost in the open air. Fortunately for grouse, the cold front that leads a mass of invading arctic air usually drops a new carpet of loose snow.

There are risks involved in bedding down under the snow. A prolonged fall of freezing rain can imprison a grouse in its burrow, making it vulnerable to predators or possibly (so it is said) even death by starvation before it can peck its way out.

John Macfie

Activity 4:
A LOOK AT FROZEN SOIL

Cut a block of frozen soil about the size of a brick and bring it indoors for observation. Place it in a metal tray to catch any water that melts. Describe the appearance of the frozen soil in the same way that unfrozen soil was described in Chapter 2. What changes occurred when the sample thawed?

Activity 5:
IS THERE WATER IN FROZEN SOIL?

Cut a block of frozen soil similar to that used in Activity 4. Weigh the block while it is still frozen. Then place the sample in a flat container inside your classroom and leave it for two or three days. Compare the mass of the thawed sample with its mass when it was frozen. Explain your findings. Place the dried sample outdoors in a waterproof container when the temperatures are sub-freezing. Leave it overnight and explain any noticeable differences the next day. Has it changed from its original condition? What was the purpose of this last experiment?

Other Activities

1. Test the composition of soil in winter using the methods described in Activities 2, 3, 4 and 6 of Chapter 3.
2. Does soil composition differ from summer to winter? Explain.

Dig in 2 m of frost on 2 city works jobs

Frost slows down builders. This is the heading of an article from the North Bay Nugget, *Ontario.*

What change in permafrost conditions caused this building in Dawson, Yukon Territory, to tilt?

Chapter 7

TRANSPORTATION AND DEPOSITION OF SOIL

Chapter 1 talked about the many serious effects of soil erosion. This problem will be discussed again in Chapter 10. In the meantime, the following activities and questions will help you learn how soil is transported and deposited. The chapter will concentrate on causes of soil transportation but it will not emphasize the harmful effects of erosion. However, always think about effects of erosion and ways of controlling it. In Chapter 10 we shall discuss these in more detail.

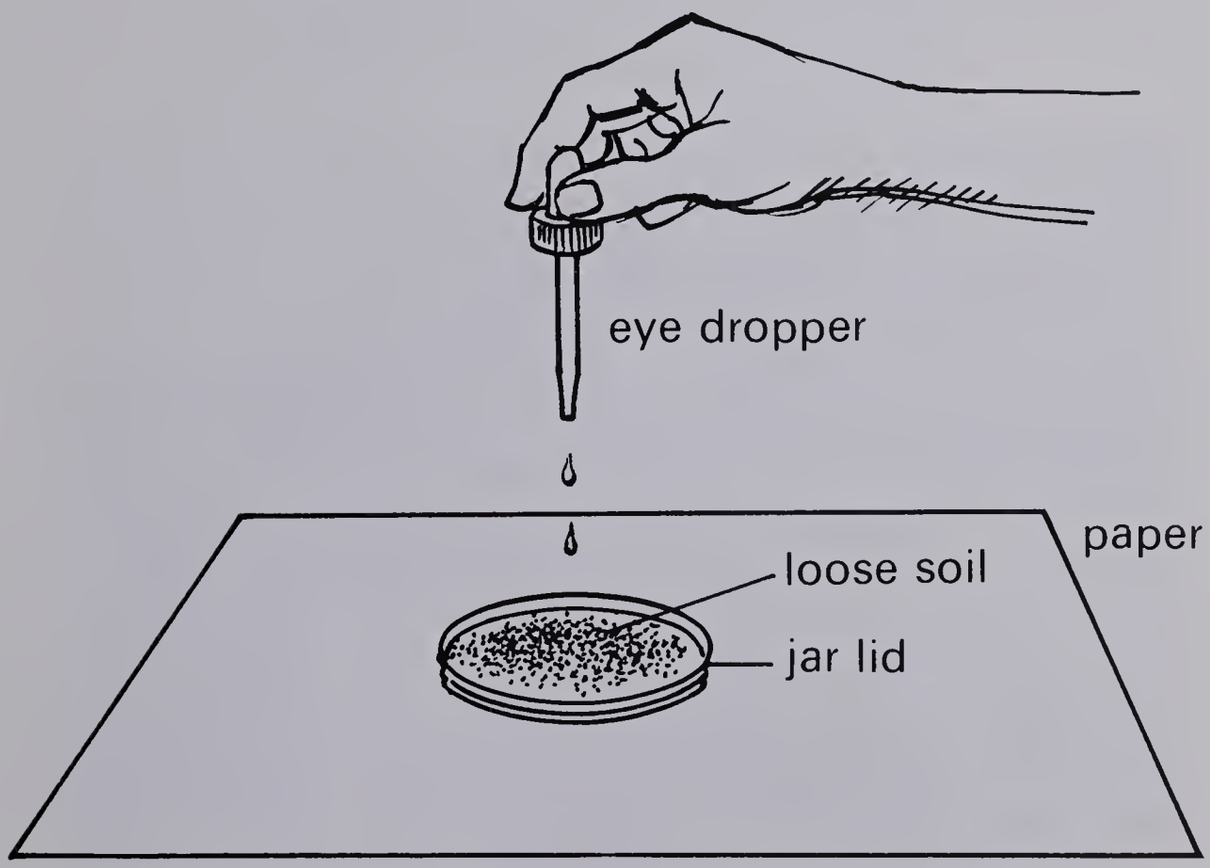
The main agents of soil transportation are water, wind, ice and animals.

List the things that you already know about the transportation of soil. Compare this with what you learn while working through the following exercises.

Activity 1: EFFECT OF RAINDROPS ON SOIL

The impact of even a drop of water may play some part in the erosion cycle.

1. Place a flat container filled with loose soil on a sheet of white paper. Let water fall, drop by drop, from an eye dropper so that it strikes the soil near the middle of the small container. Describe what you observe.
2. Let the water drop from different heights.
3. Measure the distance soil is splashed from the centre of the container.
4. Is there a relationship between the distance of soil splashes and the height at which the dropper is held? Can your findings be shown on a graph?
5. What part can a drop of water play in soil transportation?
6. Test the effects of a drop of water on packed soil.
7. What is the effect of raindrops on sodded soil?



Mud blocks 3 Parkway lanes

The Don Valley Parkway's three northbound lanes were to reopen this afternoon after being closed by a rush-hour mudslide last night.

About 20 tons* of mud slid down on the parkway.

Engineers from Metro roads department inspected the site this morning to ensure there was no danger of further slides in the area just west of the Don Mills Rd. overpass.

The northbound lanes were closed between the overpass and Bloor St.

Rush-hour traffic last night was snarled into what police called an incredible tie-up when a section of slope gave way where the parkway cuts around the base of a steep hill.

Tons of mud, loosened by two days of rain flowed across the roadway and slopped over the median guard-rail.

Police said it was fortunate that there was only one car in the path of the 30 000 square feet of slithering sod and topsoil.

The car, travelling north in the right-hand lane of the parkway, was pushed across three lanes into the median guard-rail but its woman driver was only shaken up.

Among motorists caught in the traffic jam was Hamid Jalil, who was on his way to get married at Iondale United Church, Scarborough.

A policeman obligingly radioed headquarters to notify the bride-to-be, Cecile Pringle, who was anxiously waiting at home.

*18t

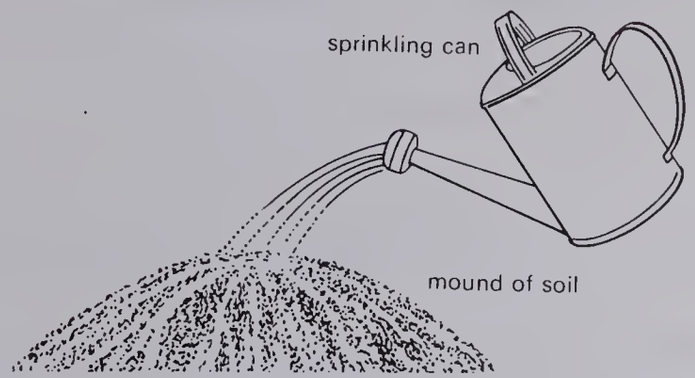
Trees to anchor parkway bank

Metro will plant shrubs and trees to stabilize a section of the Don Valley Parkway embankment where a 20-ton landslide blocked traffic April 18. Murray Browning, director of operations for Metro's roads department, said the slide was caused by a combination of underground water and surface drainage. He said other parts of the embankment have been checked and there appears to be no danger.

A new drainage system was designed to prevent another mudslide—and the humble crown vetch was also planted for additional safety. Vetch is very useful because it has long roots that help to bind the soil. Grass was also seeded.

Activity 2:
EFFECT OF RUNNING WATER ON SOIL

Build a mound of loose soil about 0.5 or 1 m high near your school. Pour several containers of water on the top and describe any changes that take place.

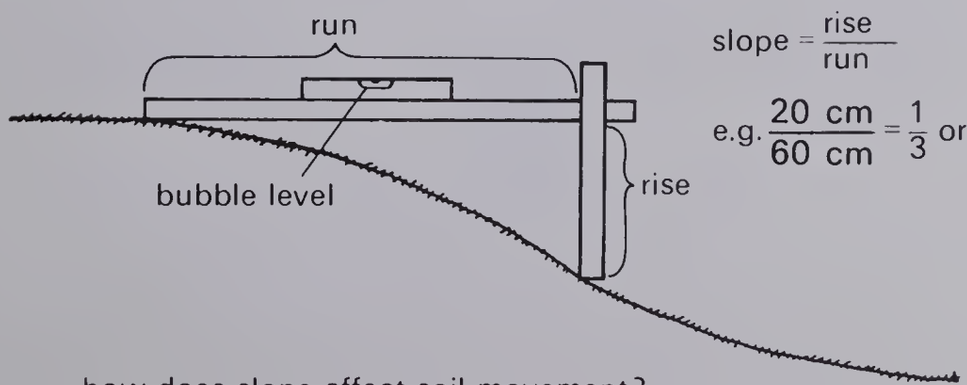


1. Why was a sprinkling can used?
2. How is this activity similar to conditions that naturally occur on some hillsides?
3. Did you observe any gully or sheet erosion?
4. Did any part of the mound slump away to form a tiny mud slide?
5. Test the effects of packing the soil and of growing grass on it.
6. How would contour furrows affect the water run-off?
7. Use this model to demonstrate other means of controlling soil erosion.

The picture on page 18 shows the effects of running water. Look for similar conditions in your locality. Could a class project be developed to improve these conditions?

How does slope affect soil movement?

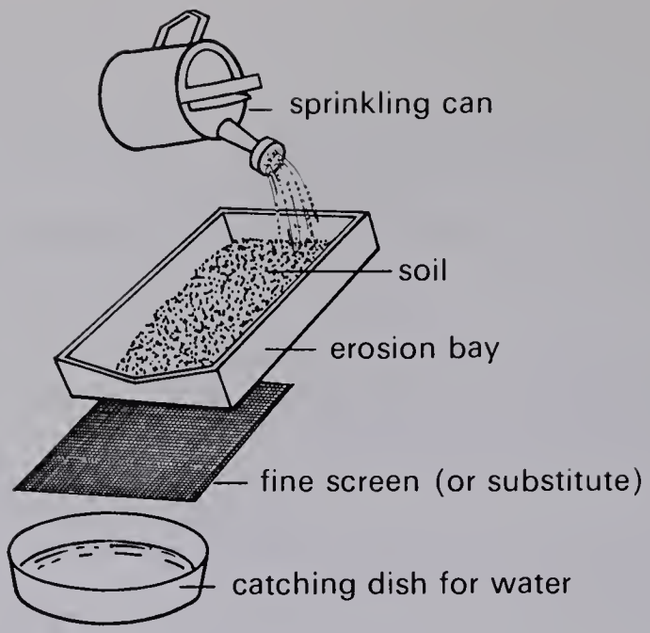
calculating the slope



$$\text{slope} = \frac{\text{rise}}{\text{run}}$$

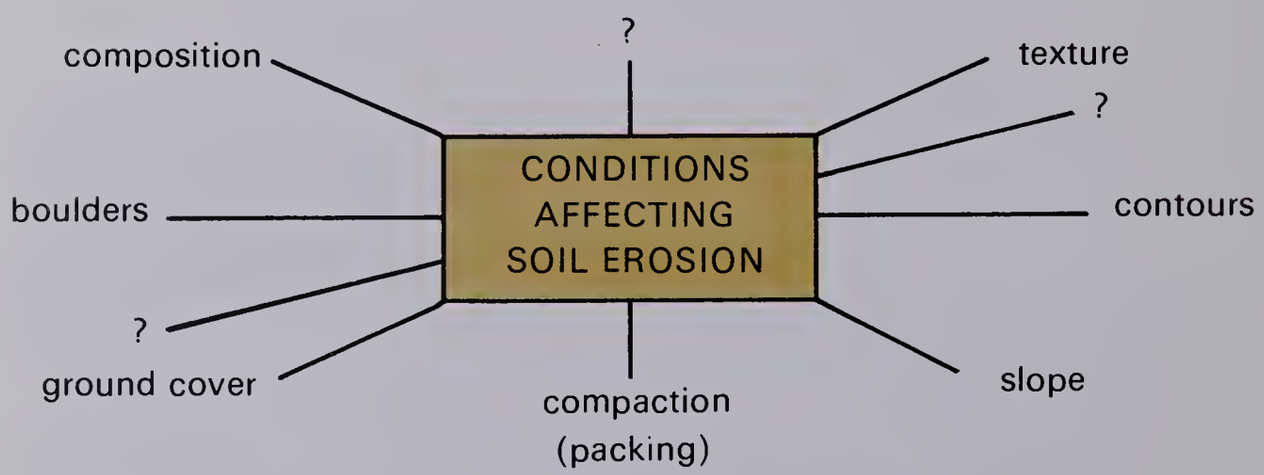
$$\text{e.g.} \frac{20\ \text{cm}}{60\ \text{cm}} = \frac{1}{3} \text{ or } 33\tfrac{1}{3}\%$$

how does slope affect soil movement?



Activity 3:
SLOPE AND SOIL TRANSPORTATION

Use an erosion box similar to the one shown above to design experiments that further illustrate the effect of running water on soil. The following chart will give some ideas.



The fine screen was used to catch the run-off. This should enable the eroded soil to be separated from the water for weighing. What other factors must be considered if the weighing is to be accurate?

Charts similar to the following will be useful in recording your findings.

AMOUNT BOX WAS TILTED	MASS OF SOIL CARRIED AWAY
0° 20° 30° 40°	

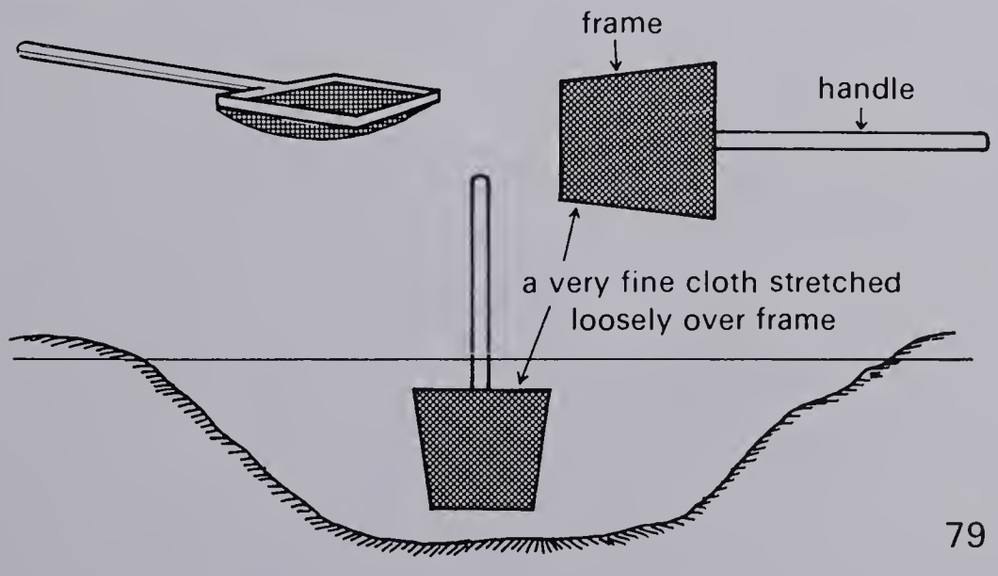
How could this same chart be modified to show the effect of the slope on different textures?

Experiment with the same apparatus to devise ways of preventing or reducing soil erosion.

Activity 4: DO STREAMS CARRY SOIL SEDIMENTS?

Prepare a net similar to that shown. Use this to test the soil-carrying capacity of a stream near your school or home. What precautions must be taken before proceeding with this activity?

Hold the catching net in a running stream for a set length of time. Remove the net and measure the amount of soil sediments collected. (Think of the techniques used in Chapters 3 and 4.)

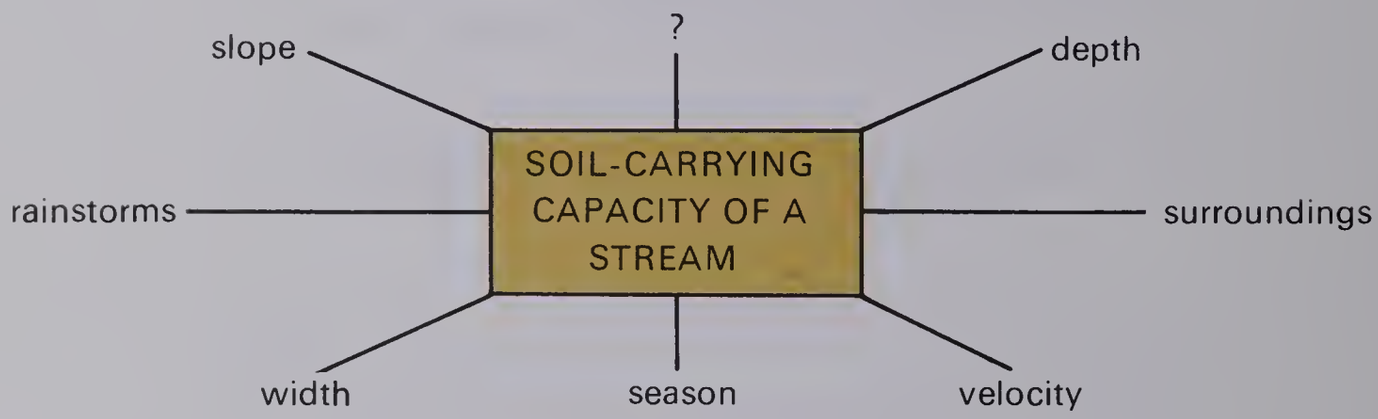


a stream profile

Could you use the small sample that was caught by the net to estimate the total carrying capacity of a stream in a given length of time? What does man do to control stream flow at different times of the year? Why? (Hint: Find out how flooding of the Red River at Winnipeg has been controlled.)

Use the activities about streams in *Studies For Open Places* and the companion book *Studying Streams,* to assist your calculations.

How do the following factors seem to affect the amount of soil being carried?



Activity 5: WAVE ACTION ON SOIL EMBANKMENTS

Study the photograph of the Scarborough Bluffs, Ontario, to see the action of waves on soil embankments. How is water changing the soil formation? What controls are there for this type of problem? Collect photographs and information about other examples of shoreline erosion. Does shoreline erosion appear to be a serious problem? Support your answer.

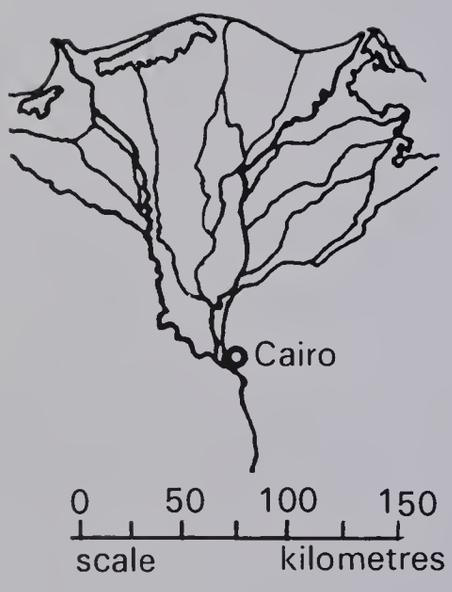
How can you build a demonstration model to show the effects of waves on shorelines?

DEPOSITION OF SOIL ERODED BY WATER

Chapter 1 looked at two situations where eroded sediments had been deposited by water. The first showed the difficulty of placing bridge piers and the second referred to the silting of a water reservoir. Such situations are repeated many times in other parts of the world. Can you find similar examples? Why does this type of erosion cause two problems?

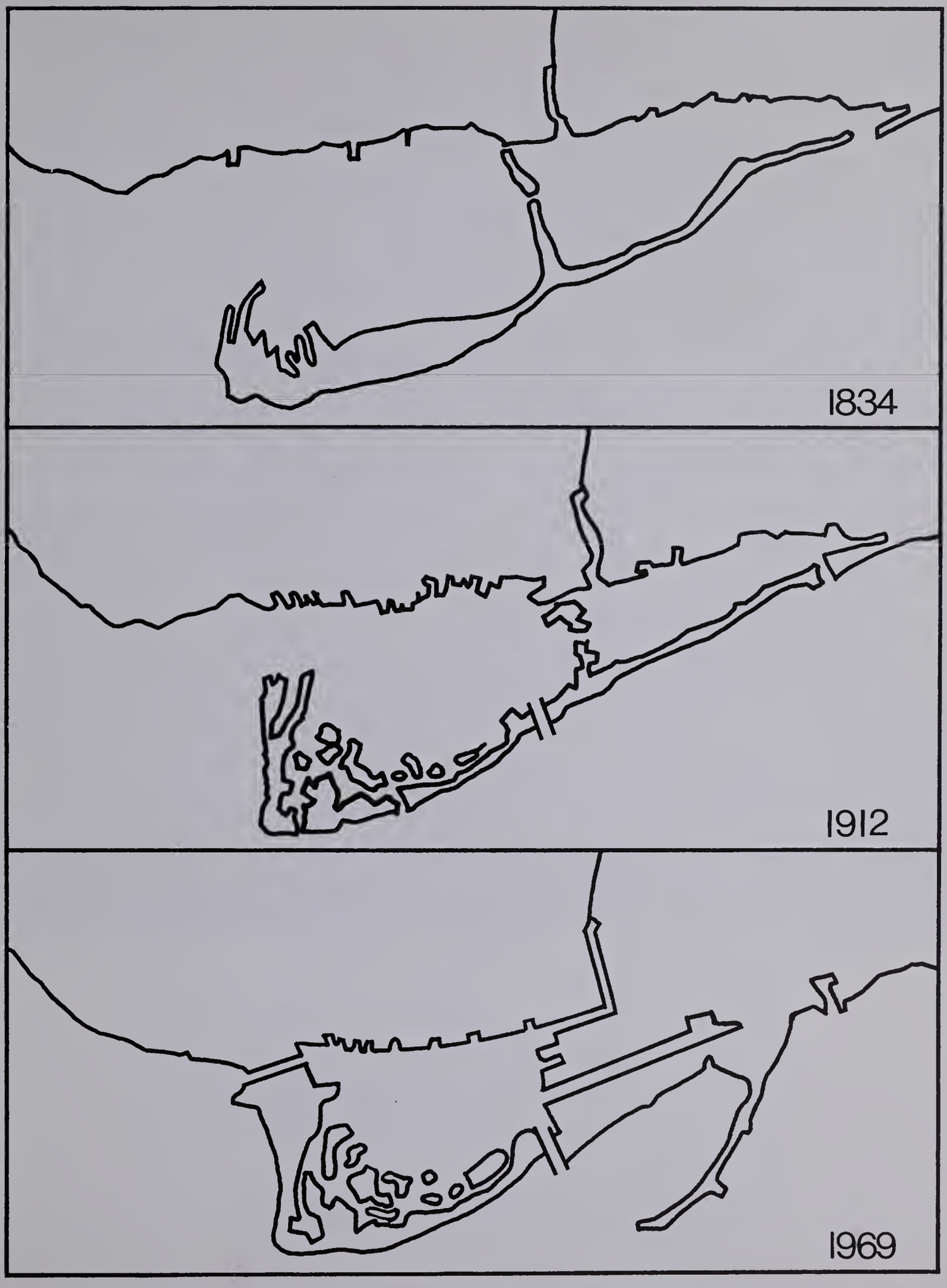
Soil deposits are also caused by water currents in large lakes and oceans. The Toronto and Boston, Massachusetts, harbours, for instance, are protected by bars of sand called spits that were partly formed by longshore currents that transported and deposited sand sediments. These bars are now small islands. The development of the Toronto water-front is shown. What changes have occurred? What different agents have probably been responsible? What changes may be expected in the future?

"Off-shore bars" is the name of another type of deposit made by water. These formations are caused by waves that erode shorelines and carry the sediments back towards the centre of the lake or ocean. The bars (sometimes called sandbars) usually run parallel to the shoreline. By making the water shallower they may create dangers. Can you think what these might be? Try to find stories about sandbars that have caused problems.



Rivers carry soil sediments and deposit them in lakes and oceans. Sometimes these particles are dropped at the mouth of a river. This may partly block the river's mouth and force the water to spread out into many smaller channels. When this happens a "delta" forms. Some of the better-known deltas in the world are those of the MacKenzie, Nile and Mississippi Rivers. Can you find pictures to compare their shapes? Why are they called deltas?

Try to find a miniature delta near your school. Build a model river so that it can form a delta. A water hose and supply of sand are useful materials. Explain your experiment.


1834
1912
1969

Here is how the sleeping giant looks from the air. Photographs like this are very useful to scientists, who can tell, for instance, that at (1) is a white birch wood and (2) is black spruce. Certain trees prefer dry soil and others wet soil, so if the kinds of trees are known then it is often possible to determine how well the area is drained. The dark area toward the top is the giant's shadow.

If special equipment is used, the height of the mountain can be worked out from photographs like this one.

THE SLEEPING GIANT

Standing on the shores of Thunder Bay at the head of the great Lake Superior, one can perceive, on looking out across the waters of Thunder Bay, a great land formation situated directly in the mouth of the Bay.

It requires no imagination whatever to see that this form resembles the sleeping body of a giant, arms folded across his massive chest as in the majesty of death. Mystery and legend surround the origin of this strange phenomenon of nature and down through the ages the following story has survived.

On an island just outside Thunder Bay, now known as "Isle Royale", once lived a great tribe of Ojibway Indians. Because of their loyalty to their gods, and their peaceful and industrious mode of living, Nanna Bijou, the Spirit of the Deep Sea Water decided to reward them.

One day he called their Chief to his great Thunder Temple on the mountain, and warned him that if he told the secret to the white man that he, Nanna Bijou, would be turned to stone and the Ojibway tribe would perish.

The Chief gave his promise, and Nanna Bijou told him of the rich silver mine, now known as "Silver Islet". The Great Spirit told him to go to the highest point on Thunder Cape, and here he would find the entrance to a tunnel that would lead him to the centre of the mine.

Apparently the Chief and his people found the mine, for the Ojibway became famous for their beautiful silver ornaments.

One day, however, a Sioux scout learned of the Ojibway's secret. As he paddled off to tell his tribe he encountered two white men and told them what he had learned. As the white men neared the lovely isle, the sky grew dark, a thunderbird screamed, the water churned to foam and a mighty upheaval took place.

Nanna Bijou folded his arms and laid down to sleep by the secret he had guarded for centuries.

Will he stay for ever?

Do you know of similar legends? Perhaps it might be interesting to make a collection of legends to share with others. One class found it very interesting to write their own legends about local history.

WIND MOVES AND DEPOSITS SOIL

Some of the effects of wind-blown sand were shown in Chapter 1. Look at these again. Use the information you already have to answer the following questions.

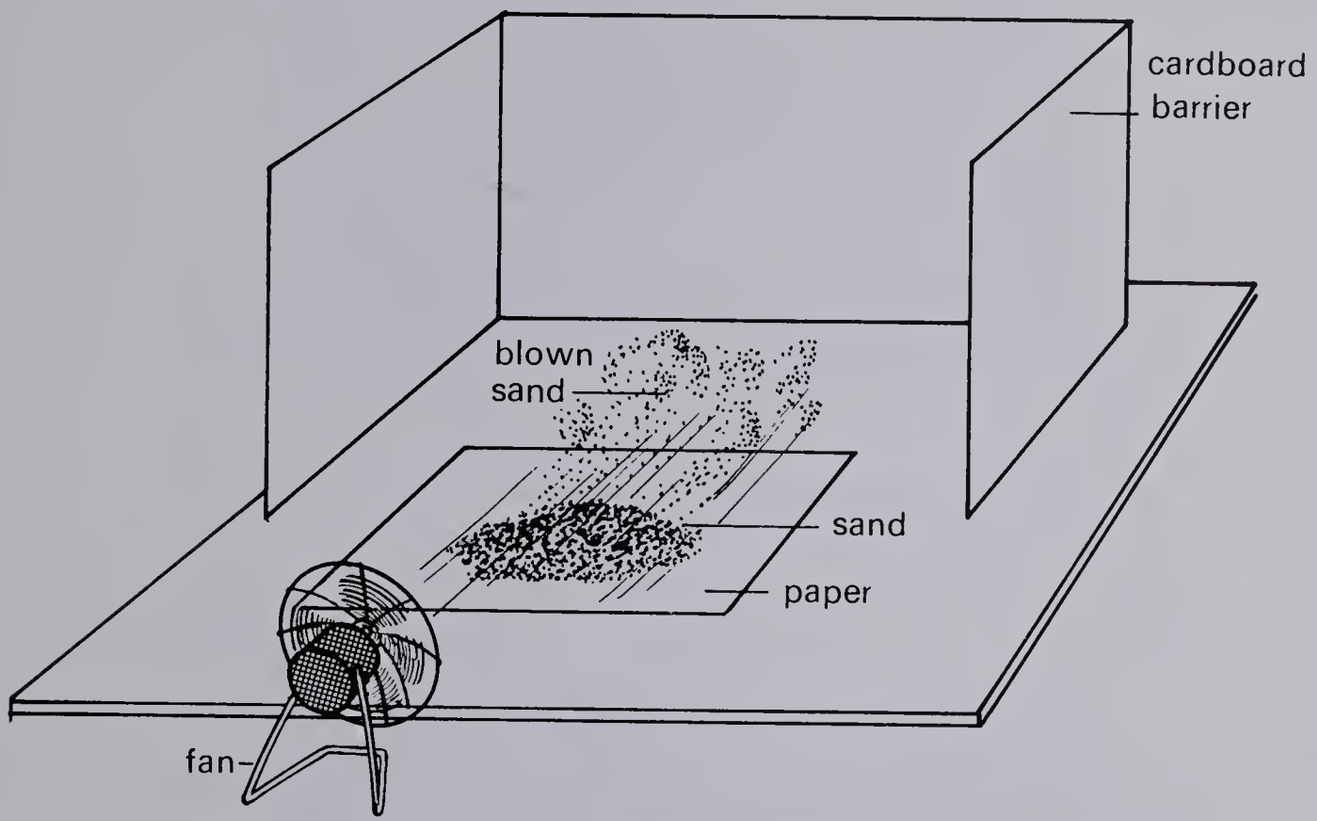
1. What types of damage may be caused by wind-blown sand?
2. What factors seem to help move soil?
3. Where is wind erosion most serious?
4. How does climate influence this type of erosion?

Record your answers to these questions so that you will be able to add new information that may be found when you are working with the activities and problems which follow.

Activity 6:
WHY CAN WIND BLOW SAND?

This activity will help you experiment with some of the factors affecting movement of soil by wind. Perhaps it will help you to expand your answer to question 2.

Use a fine, dry sand and assemble the experiment as shown. Let the fan run for a set time and then measure the amount of sand moved.



Compare the results with the following calculations.

mass of sand on paper at beginning	= 534 g
mass of sand on paper after blowing for 2 minutes	= 381 g
mass of sand removed	= 153 g

Replace all the sand on the paper, dampen it with some water and repeat the experiment. Keep all the other conditions

the same. Record your findings in a chart similar to the one below.

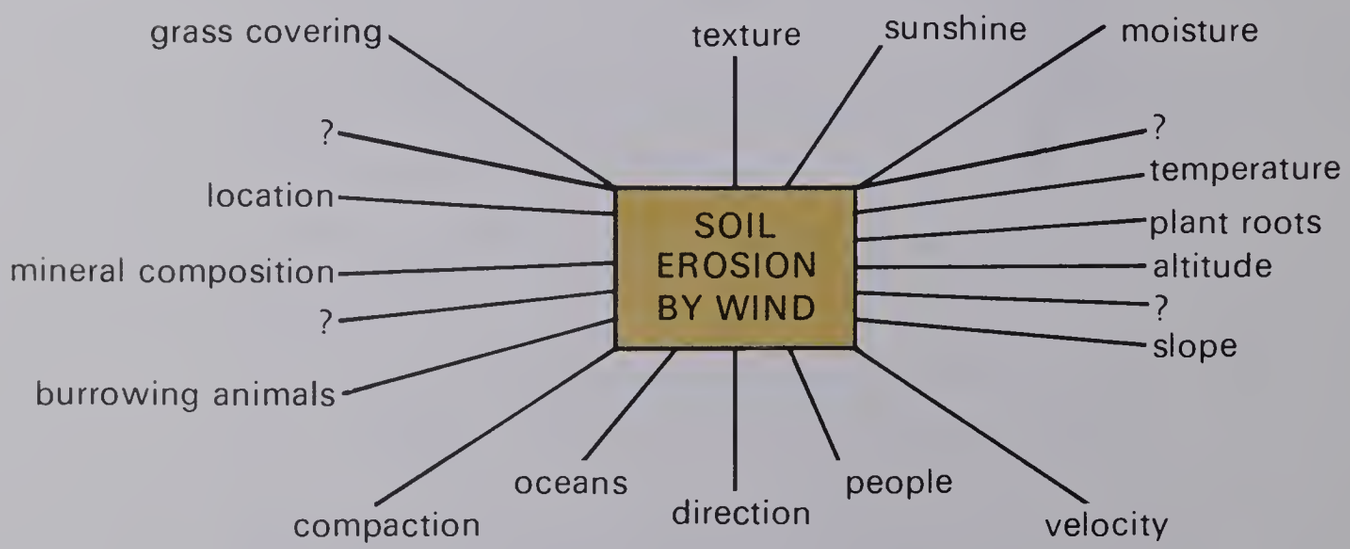
mass of dampened sand at beginning	=	
mass on paper after blowing	=	
mass removed	=	

What conclusions may be drawn from this experiment?

Activity 7: DESIGNING ADDITIONAL EXPERIMENTS

Dampness is only one factor that affects the blowing of soil. The following chart lists some of the others. It also, however, includes some things that do not influence wind erosion. Which are important considerations for wind erosion?

Set up experiments similar to those of Activity 1 to test your predictions. Always keep records.



The following photograph shows some effects of wind erosion. Notice the patterns that have developed. Did any similar patterns show up in your experiments? Find pictures to show other examples of sand deposited by wind.

Does drifting snow leave similar patterns? Support your answer.

ICE MOVES SOIL

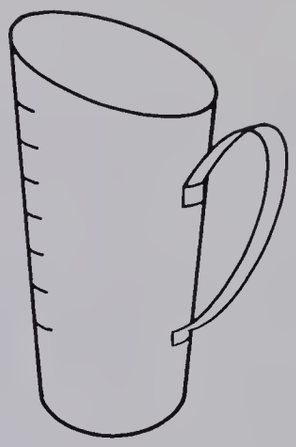
Chapter 5 discussed the part ice plays in making soil. Glaciers carrying rock particles cause grinding and breaking, and thus produce soil particles. The gravel in this pit was deposited during our most recent ice age.

These moraines were also deposited by glaciers.

Can you discover any glacial deposits in your area? What other information can you find about glaciation?

Activity 8:
HOW SOIL CAN GET CAUGHT IN ICE

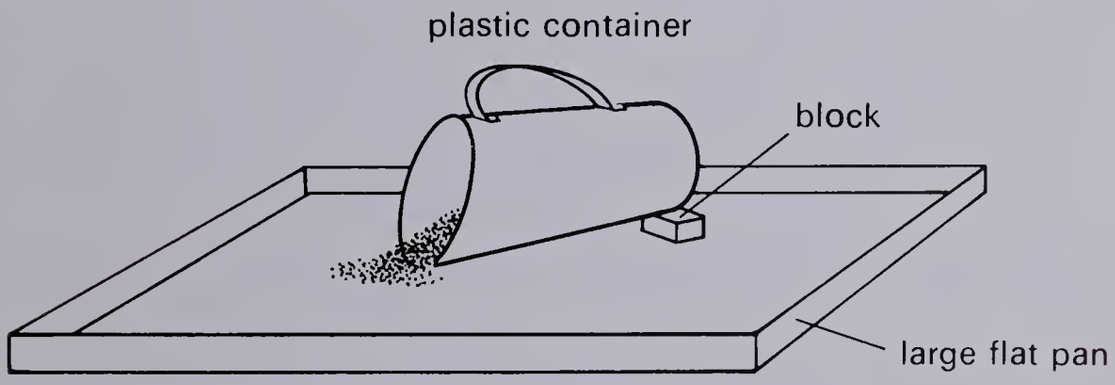
This activity will give you an idea of how soil particles can get caught in ice and be moved to a different location. It may also be used to produce a tiny model to show how glaciers dump soil materials as they melt.



Place about 5 cm of water in a tall plastic container and freeze it. Without allowing the ice to melt, add a handful of sand and about 5 cm more of water. Freeze it again.

Repeat the addition of sand and water until the container is filled. You have now built up a block of ice that has sand mixed throughout. How long will the sand remain in the ice? Could this ice transport the sand? How is this model similar to a glacier?

Place the container on its side with the bottom slightly raised and allow it to melt slowly. Find a way to keep the ice from slipping out of the container.



How was the sand deposited when the ice melted? Can you explain your observations? Would it make any difference if the water was allowed to escape? Could a metal juice can be substituted for the plastic container?

ANIMALS MOVE AND DEPOSIT SOIL

Among all the animals that take part in soil transportation, man is the most active. To remove minerals, he quarries, crushes and transports. The photograph of the Steep Rock Mine (below, left) is a good example of this.

Road building also causes man to change the lay of the land. The photograph is of a road cut through limestone. The rock that was taken from the cut was crushed and used as the base for another part of the same highway. In this building operation, the soil particles were produced and transported. (Note that the limestone has begun to weather.)

Some Things to Think About

1. Are there man-made soil-producing activities in your locality?
2. Do you think gravel operations can harm our landscape? If so, what preventative measures might be taken?
3. Try to find other examples of soil being transported by man.
4. In what ways do other animals move soil? What are the effects of such activities? (Hint: Do not forget that worms are animals.)
5. What have you learned about the transportation and deposition of soil? How does this compare with the list you made before beginning this chapter.
6. List any questions that may still be unanswered.

Why is this boulder called a glacial erratic? This one is in southern Ontario.

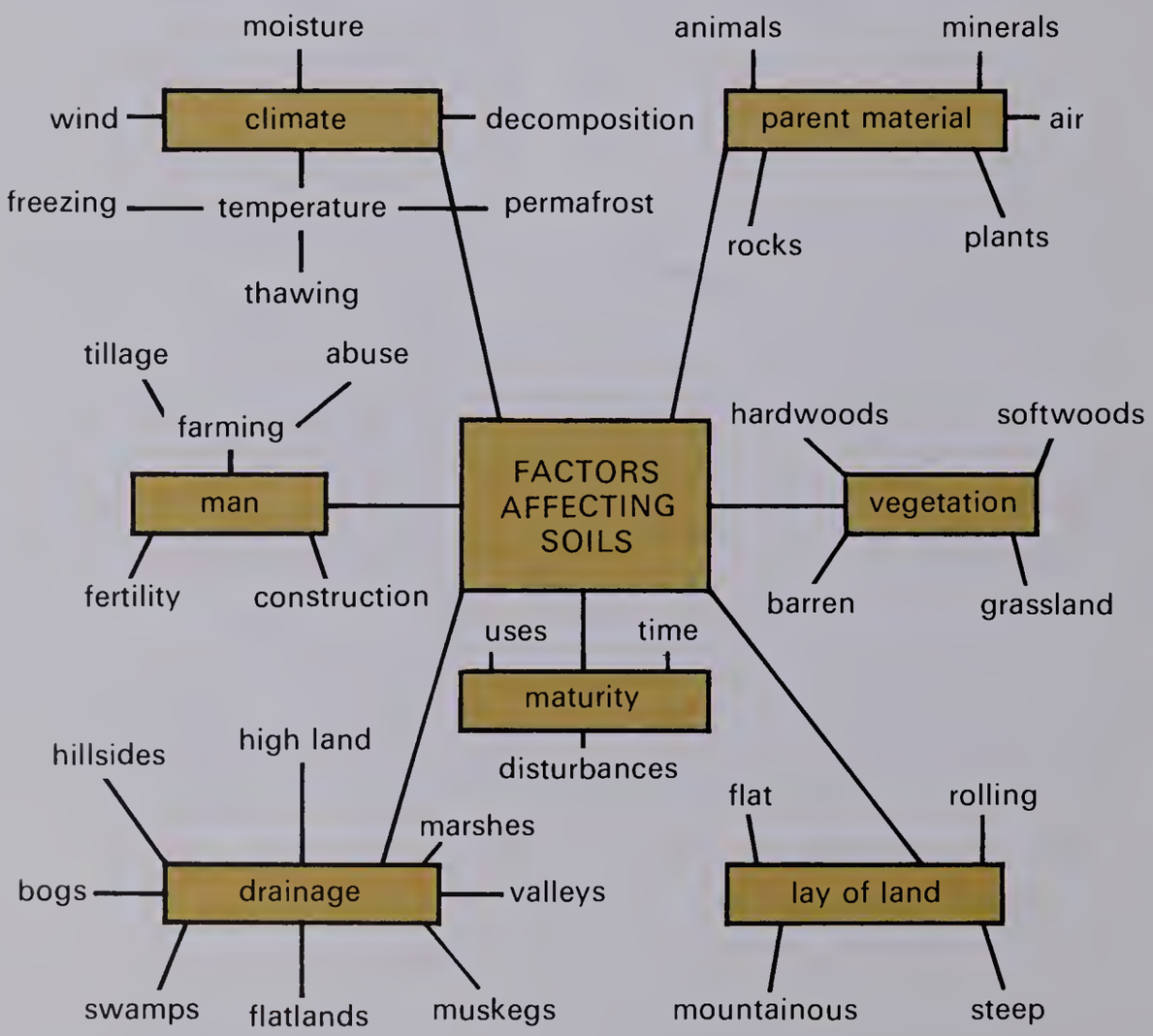
Chapter 8

PROFILES AND SOIL RELATIONSHIPS

This chapter will mix new ideas with some that you learned in previous chapters. You will also use soil profiles to develop further studies. (See page 96 for a diagram of a profile.)

SURFACE AND SUBSURFACE SOILS

There are many factors which affect soil conditions. Some of these are listed in the following chart. Use it to discuss the ways in which the different factors are related to each other. Check many sources for additional information to help you understand these relationships.



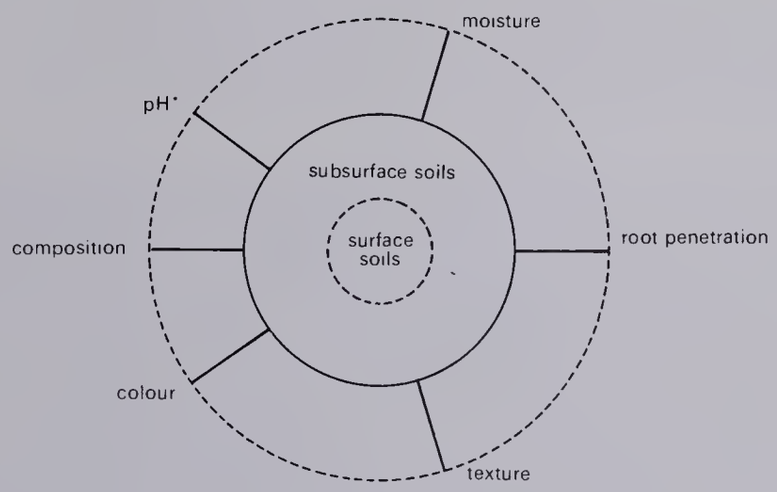
Explain how some of the major factors that affect soil are related. Try to make a chart that includes more ideas than the one shown on page 94.

Many of the activities already suggested in this book have not been concerned with the depth from which the soil samples have been collected. This chapter, however, will include that factor.

The upper layer, known as the "A" horizon or topsoil, has many characteristics that are not found in the deeper "B" and "C" horizons (layers). Let us now look for some of these differences.

PUZZLE

How may this drawing be used to show relationships?



(Hint: Think about venn diagrams)

*pH is a measure of alkalinity or acidity. Directions for determining acidic or basic qualities are in *Studies for Woodlands.* You can buy kits to measure pH, nitrogen content and other soil characteristics. Farmers use this type of information to chose the most suitable mixture of fertilizer for their lands. Home owners also find it useful to know the pH count of garden soils. Blue grasses, for instance, grow best in a neutral soil (pH = 7). When the pH of a lawn of blue grass is sour (pH less than 7) lime or another neutralizing agent must be added.

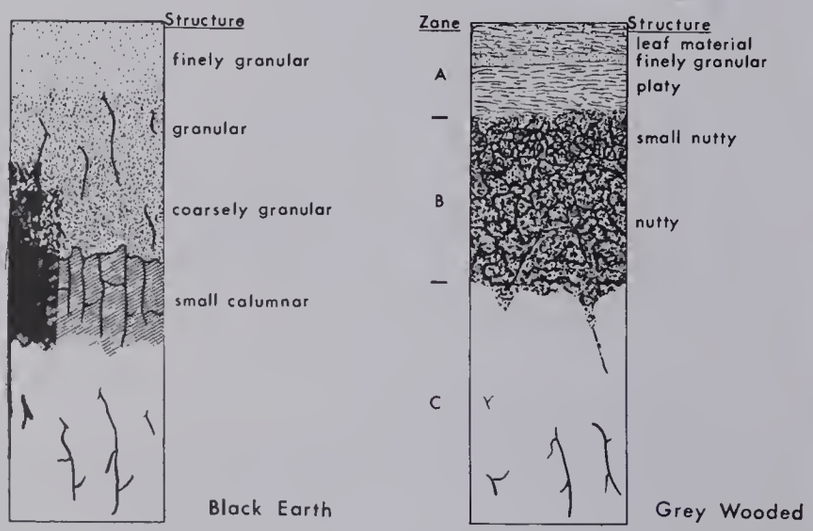
Activity 1:
PREDICTING SUBSURFACE SOILS

What differences would you expect to find between surface and subsurface soils? Use what you have already learned to predict what you would expect to find if you dug 2 m or more into the ground. Record your predictions so that they may be compared with actual findings when you observe soil profiles. Profiles are described in the next two activities.

Use the chart in the puzzle to help you.

Activity 2:
PREPARING SOIL PROFILES

A soil profile is a vertical cut through all the major soil horizons. It gives an opportunity to study subsurface soils as they naturally exist. Some profiles must be several metres thick to include all the different soil layers.



Two major soil profiles found in Canada.

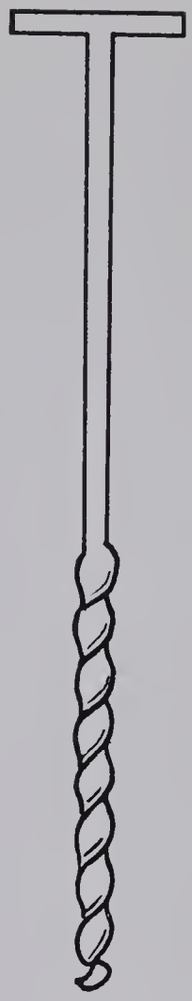
A well-drained profile.

Before digging soil profiles, obtain permission, and protect people from falling into the opening. Refill the excavation afterwards.

Many soil profiles are already available. Look for ex-

cavations for house basements, drainage ditches, gravel pits and road embankments.

Sometimes embankments must be "cut back" to see the true soil profile. This cutting eliminates changes that may have taken place since the surface was exposed.



This soil auger can be made from an old wood auger and some steel piping.

COLOUR GUIDES

You have probably noticed the wide variation of soil colours. Though colour is not usually used by soil scientists for classification it can provide many clues about the properties of soil. Very dark soils, for instance, are usually high in organic material. Drab or mottled soils are frequently associated with poor drainage conditions. Can you find other causes for colouration?

Studies for Open Places gives some ideas for beginning soil colour explorations. Pages 66 to 72 suggest ways to make colour guides. These can be helpful standards for comparing soil colours at different places and in different horizons.

Soil profiles help to solve mysteries of history. When archaeologists dug this hole at an old Indian village in Pickering, Ontario, they found a dark streak in the soil. This was wood mould, all that was left of a wooden stake that was once part of an Indian hut. By finding several of these "post holes", the diggers were able to work out the shape of the long-lost home.

If you have used the activities from *Studies for Open Places* you are probably already familiar with the use of a soil colour guide. If not, you will find the following paragraphs useful.

Look at the soil relationships chart on page 100. Use it to relate findings about soil. As observations are made on the same chart about colour, texture, moisture, composition and vegetation, it should be easier to see any relationships that may exist. Look for patterns that may suggest connections among various soil conditions. Is colour, for instance, related to moisture, composition, texture or vegetation? To answer this question, you can see the need for carefully collected data.

The "soil relationships" chart also indicates that observations will be made at different locations. If this is to be done, standards for comparisons must be used. Can you now see why it will be necessary to prepare a colour guide(s)?

Activities 3 and 4 will help you prepare to use the "soil relationships" chart.

Activity 3: MAKING "STANDARDS"

1. *A Colour Guide.* Use the ideas from Activity 1 on page 66 of *Studies for Open Places*. Adapt these, if necessary, to suit the colours in the chart on page 100. It may be necessary to make a colour guide for each of the different colour groups (e.g. very dark, drab, medium and light). Why would each team of pupils need identical colour guide(s)? Why is it better to moisten soil before recording its colour?
2. *Texture Guide.* How could four different sieves (see Chapter 4) be used as standard measures to estimate texture? Would percentages be useful in recording this data?
3. Moisture content may be used as a partial measure for drainage conditions. Other factors, such as recent rain-

falls, must be considered. Write descriptions to accompany the following diagrams to tell when soil is very moist, moist, dry and very dry. Perhaps it would be useful to make a set of "moisture description cards" for each team that will be making comparisons.

water drips
wet

soil sticks
moist

particles break away
dry

4. *Other Factors*. Use the help of your teacher and classmates to decide how composition and vegetation will be recorded on the chart. Should you also consider tillage and climate? Note particularly if certain plants seem to prefer a particular kind of soil.

Activity 4: USING PROFILES TO OBSERVE SOIL RELATIONSHIPS

Make charts similar to the following one. Use them to record information from different soil profiles. Change the chart as necessary.

Decisions to be Made

1. Would it be better for all teams to practise observing the same profile?
2. How many teams will there be and how many profiles will be studied?
3. Where are the profiles? Would the suggestions on page 30 be useful?
4. How will relationships be explained after all the raw data is collected and organized?
5. Do you intend to make notes of additional questions as you work through this activity?

SOIL RELATIONSHIPS GUIDE

profile study # _____ location _____ date _____

COLOUR (when moist)	VERY DARK					DRAB					MEDIUM					LIGHT					
	black	very dark grey	very dark brown	dark reddish		dull grey	olive	blue-grey	dark brown	dark yellow (spotted)	brown	yellow-brown	red-brown	yellow	light red	pale yellow	pale reddish	pale yellow-brown	light grey	white	

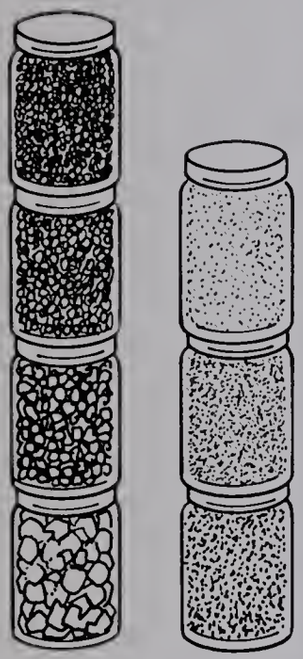
TEXTURE (look back to Ch. 4)	COARSE	MEDIUM	FINE	VERY FINE	
"A"					
"B"					
"C"					

MOISTURE (use information from Ch. 3)	VERY MOIST	MOIST	DRY	VERY DRY	
"A"					
"B"					
"C"					

COMPOSITION (describe, using information from Ch. 3)	
VEGETATION (describe)	
OTHER (describe)	_____ _____ _____

Activity 5:
MODEL SOIL PROFILES

The drawings show ways of bringing soil profiles indoors. Use similar methods for recording findings from soil profiles.



Activity 6:
MAKING MICROMONOLITHS

The soil scientist takes samples of soil from the different horizons and glues them to a micromonolith card so he can compare them with other soils. Here is how you can make the soil cutters and your own soil micromonolith. Why do you think the name micromonolith was chosen?

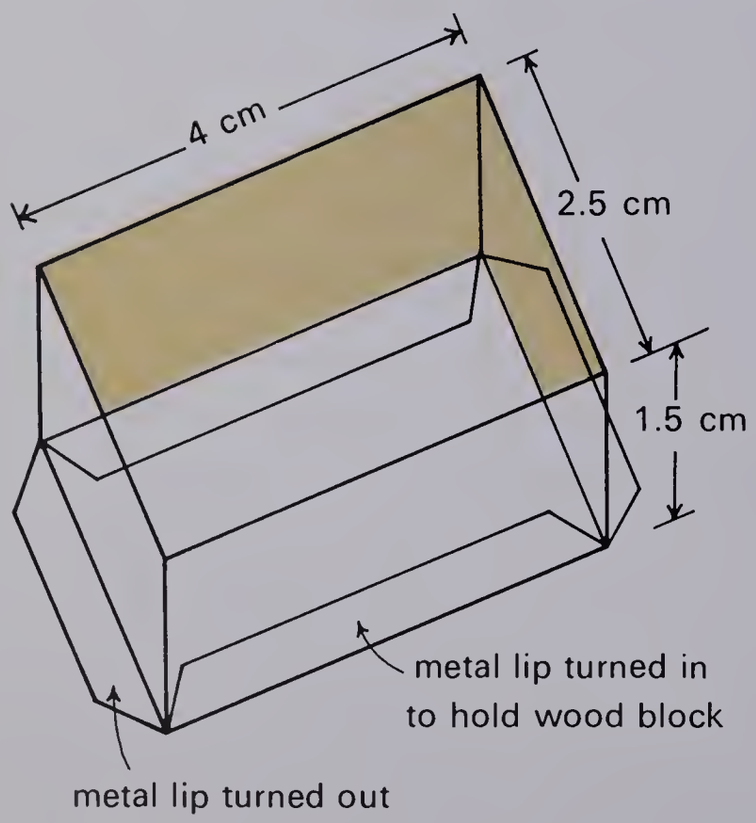
Materials

1. Blotting paper
2. Cardboard 11 cm x 20 cm
3. Knife
4. Clear waterproof cement
5. Plastic spray

6. Metal soil cutter (approx. 1 — 4 cm x 2.5 cm x 1.5 cm. Spice can will work — cut out bottom).
7. 1 cm block of wood (cut wood to fit inside cutter, leaving 0.5 cm space between top of block and cutting edge of cutter).

Method

1. Place wood block in cutter.
2. Cut blotting paper to the size of the wooden block so it will fit inside cutter.
3. Place blotting paper (cut in step 2) on the wooden block.
4. Cover the entire blotting paper liberally with waterproof cement.
5. Cover same size area on the card with cement.
6. Push cutter into soil (use side of soil pit, road bank or other soil bank).
7. Push knife into soil behind cutter and pry out. This keeps soil attached to the blotter.
8. Trim loose soil away from the cutter, to approximately ¼ of an inch thickness.



SOIL MICROMONOLITH CARD

soil sample — horizon, colour, texture, depth

soil sample — horizon, colour, texture, depth

soil sample — horizon, colour, texture, depth

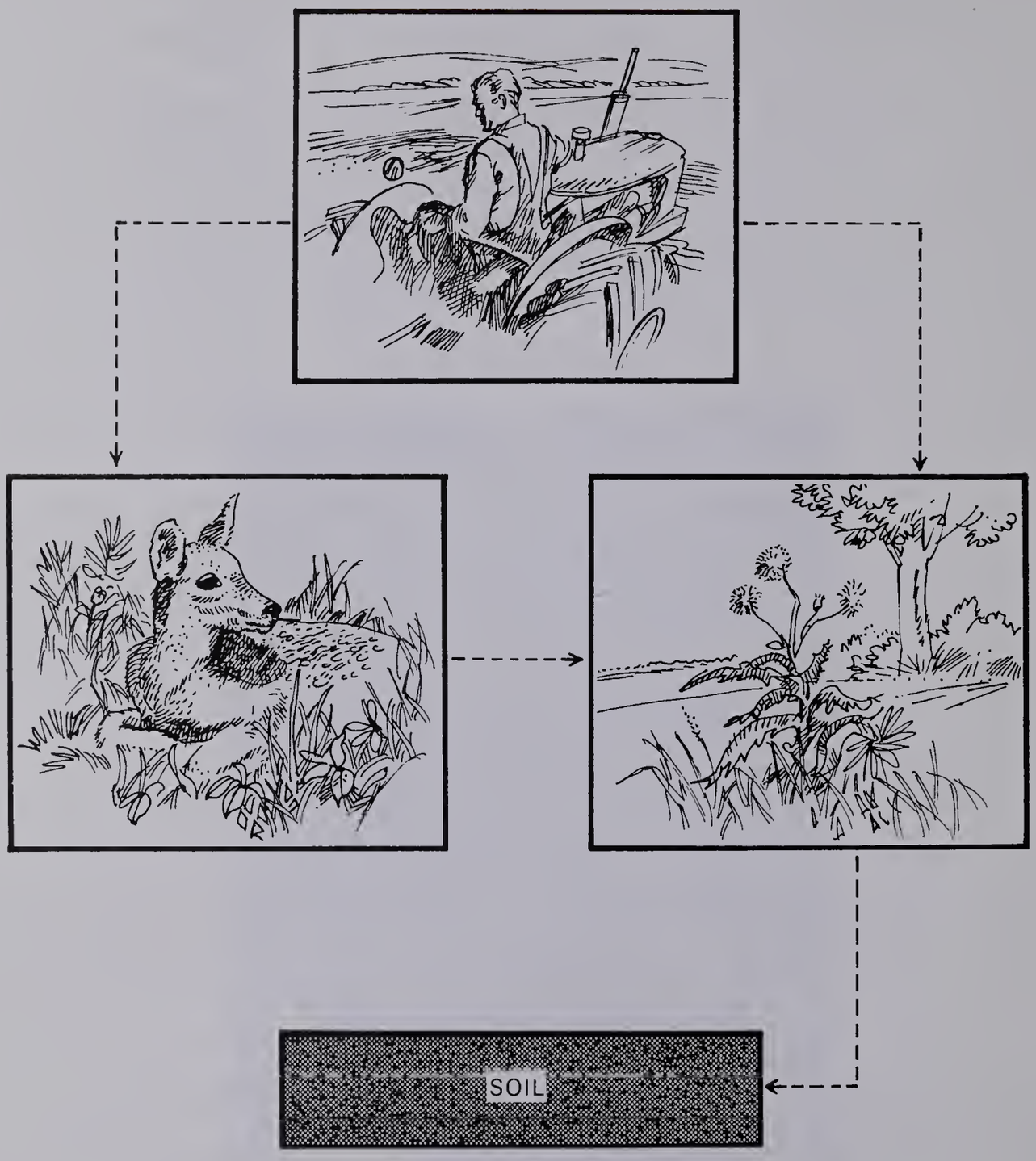
9. Push the block, blotter, and soil upward through the cutter until blotter and soil are above the edge of the cutter.
10. Slide the soil sample and blotter off the wood block into cemented area of card.
11. Take samples until all soil layers in the profile have been cemented onto the card (generally three: topsoil, subsoil, parent material).
12. Let the soil samples dry, and spray with plastic spray.
13. The thickness, pH, colour, texture of each layer can then be written on the card beside each sample.

WOODLAND PROFILES

Do woodland soil profiles appear to be different from those of other locations?

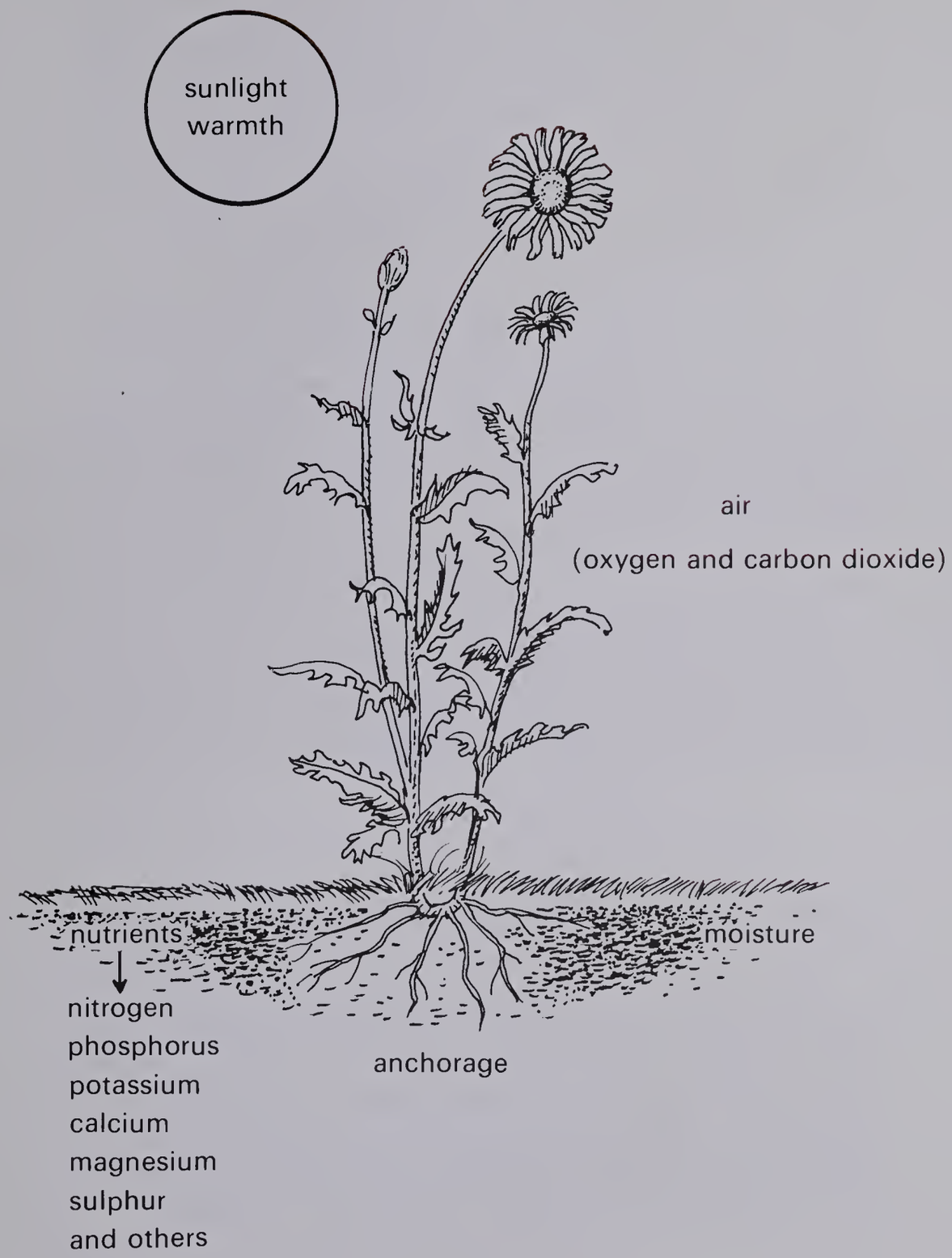
Chapter 9

PLANTS AND SOIL



Put the story of the sketches into words. Discuss the story with your classmates.

THE NEEDS OF PLANTS

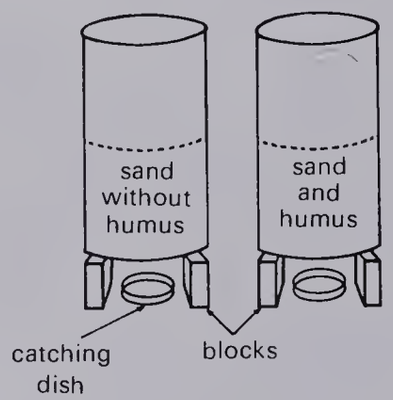


Moisture is one of the needs of plants. Water is absorbed from the soil through the roots, so plants partly depend on soil to hold water. Activity 5 in Chapter 4 dealt with the effect of texture on the water-holding capacity of soil. Activity 1 of this chapter keeps the texture of soil constant while it tests the effect of humus on water-holding capacity. Before you start the experiment, suggest what you expect to find.

Activity 1: DOES HUMUS AFFECT WATER-HOLDING CAPACITY?

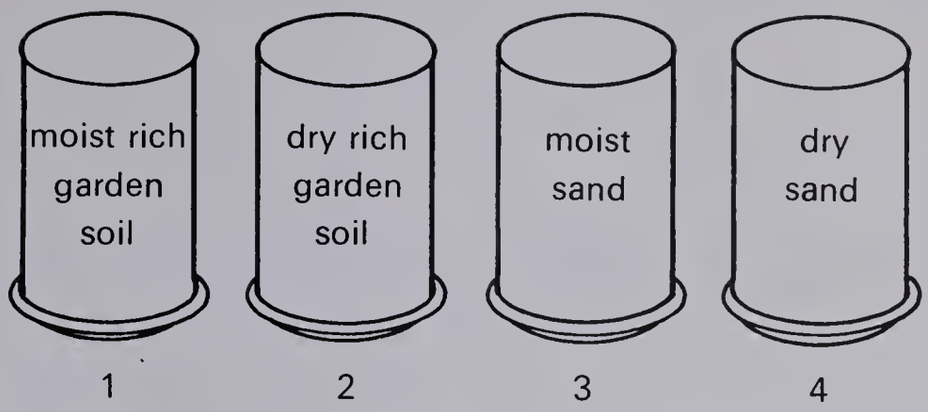
Divide a sample of beach sand into two parts. Add humus to one part by thoroughly mixing it with rotting leaves that you have dried. Use the following equipment to test its effects on water in soil. (Peat moss may be used instead of leaves.)

How did the humus affect the rate of water penetration and the amount of water held?



Activity 2: DO VARYING CONDITIONS AFFECT GROWTH?

Plant seeds in each of the soil conditions shown in the diagram opposite. Why should the same kind of seeds be planted at the same depth? Water cans one and three each day. Once the plants begin to appear above the soil's surface record their rate of growth. Did you keep all other conditions, such as the amount of sunlight, the same?

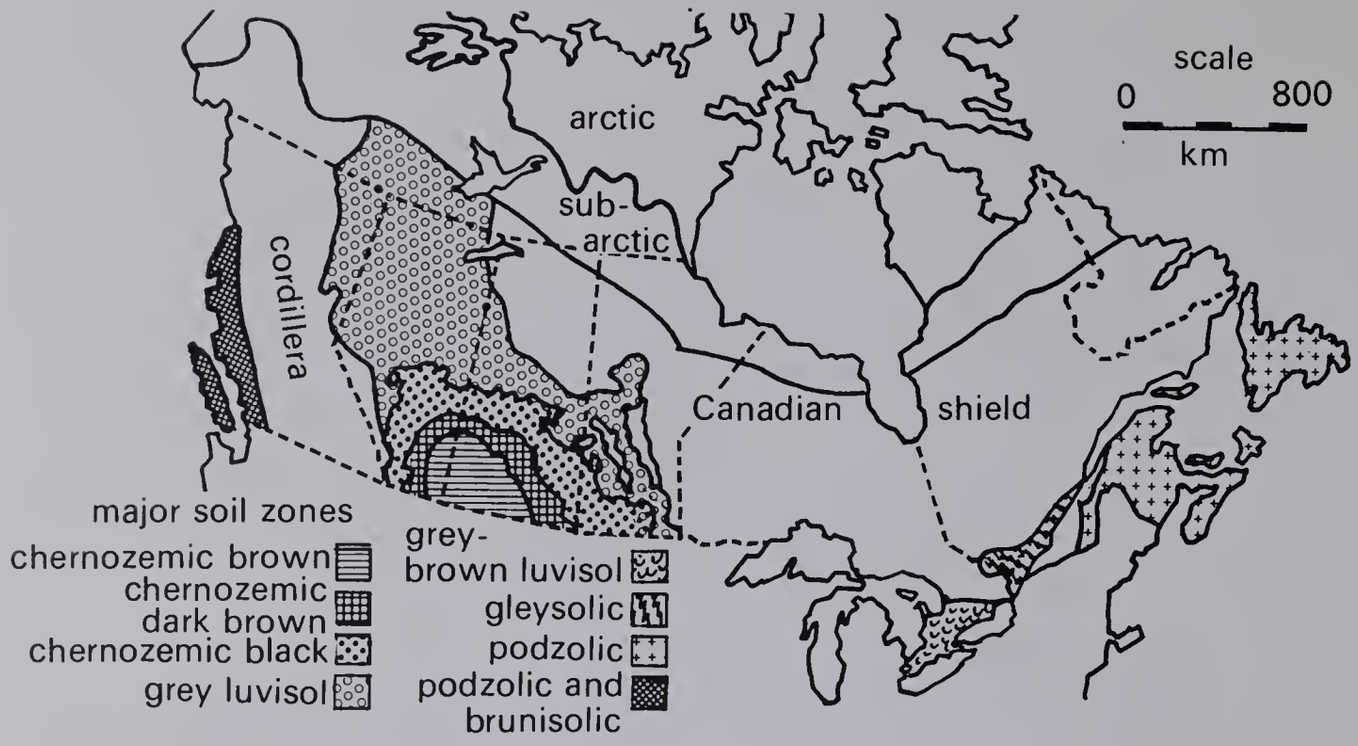


Punch holes in the bottoms of the cans.

MEASUREMENT	CAN #1	CAN #2	CAN #3	CAN #4
1				
2				
3				
4				
5				

Consider These . . .

1. Which seeds are most suitable for this type of experiment?
2. In what other ways could your results be recorded?
3. Experiment with other variables such as soil texture, composition and fertility. Design your experiments so careful comparisons can be made and always attempt to explain your results. Modify the experimental design of Activity 1 to test such variables as the use of common fertilizers.



This map shows the main soil zones of Canada.

4. Look at the companion book *Studying Plants,* and *Animals and Plants* for many other ideas about plant growth. The book *Growing Seeds* will provide another useful reference. The last two books are listed in the "References" section at the back of this book.
5. Experiment to find the effects of using too much fertilizer. Place a handful of lawn fertilizer (e.g. 7-7-7) on a small patch of healthy sod. Leave it for a few days and observe. (Hint: Pick a place where it does not matter if you kill the grass.)
6. Clover and other crops are grown mainly to enrich soil. Can you explain other instances where plants are grown for this purpose?
7. Study agricultural handbooks to find out the proper nutrients for fertilizing.
8. Discuss the possible dangers that excess fertilizing of soil may bring to animals.
9. In recent years, many people have moved from rural to urban areas. Discuss the possible outcomes of these moves.

10. Why has Canada become one of the world's leading wheat–growing countries? Are there dangers to the agricultural economy of a country that emphasizes one such crop? Should Canada give away surplus wheat? Support your answers with data gathered from newspapers, interviews, books, and so on.
11. Research George Washington Carver's work in developing peanuts as a crop with many uses.
12. In what ways has man improved the agricultural conditions of our country?
13. Gaze into a crystal ball and predict the types of farming that may be developed in the next 100 years.

Chapter 10

SOIL CONSERVATION

POLLUTION AND ITS CONTROL

In 1970 the Canadian Broadcasting Corporation telecast a programme called "The Deadly Mist". It began as follows:

> "Good evening. I'm Stanley Burke. This is a programme about the web of life itself, and what man is doing to that web, the web which links every living creature, which links us with the most minute micro-organisms of the sea. For us, for our health and well-being, probably no products of our genius have been more beneficial than pesticides. But now we're beginning to realize that we can't kill our fellow creatures without affecting ourselves and perhaps endangering ourselves. How seriously? Is it exaggerated?"

Later, in the same programme, we were shown parts of British Columbia's Grand Forks Valley where dairy farms had been forced to close. The reason: poisoning from pesticide.

One farmer explained how he had realized his life's dream when he was finally able to purchase a dairy farm. A year later he had to go out of business. The milk from his herd was poisoned by a pesticide that had apparently been transferred from the soil. This had been absorbed by the plants that were used for feed. The animals ate the polluted feed and transferred the problem to the milk, making it unsafe for human use.

1. What is the long-term danger of this type of pollution?
2. Would it be fair to destroy the farmer's herd?
3. What kinds of safeguards must we develop to prevent this type of problem from spreading?
4. In what ways might fertilizers cause similar damage?
5. Do you think the good things man does to his environment outweigh the bad? Give reasons.

6. Examine the sample of pollution shown in the following picture. What is happening to the soil? What can be done to prevent these problems? How could your class use teamwork to help?

Find areas in your community that might be similar. What action can be taken? What community groups are available to offer assistance?

Organize a team to attack problems of pollution. Remember that some kinds of pollution, particularly those caused by industry, are very expensive to control. Companies will not have enough money to correct everything immediately.

OTHER ASPECTS OF SOIL CONSERVATION

Water erosion, wind erosion and farm management are other factors that need attention when discussing soil conservation. Many of these factors have already been presented in Chapters 1, 3, 4, 7 and 8. Review them to help you answer the questions that accompany the following pictures.

1. Why has this erosion been allowed to get started?
2. How can such situations be avoided?

To protect the soil around newly-planted citrus fruit trees, millet was sown. In the area to the right, not enough was used, so rains washed away precious topsoil.

What has occurred between the "before" and the "after" situations?

These old tires have been wired together and placed on an eroding stream bank.

1. What has made some of them disappear in the lower photograph?
2. How can you tell that the two photographs were taken at the same location?
3. List ways in which other materials (brush, wire, netting, rocks . . .) could be used. See photo on page 115.

Farm Manure

Barnyard manure is one of the best fertilizers. It supplies not only plant nutrients, but adds organic matter to the soil. This organic matter improves the physical condition of the land and helps it to hold moisture and resist erosion. Manure is rather low in phosphate, so for best results phosphate fertilizers generally should be used on manured land.

1. Why is it important to maintain soil fertility?
2. What is the value of organic matter?

Use other parts of this book and other sources to support your answer.

What is the value of strip cropping?

What different conditions are illustrated by these two pictures? What must be done to help the situation where the soil has cracked? How might this cracking affect plant growth?

Vegetable trials on bog land in Newfoundland.

This is an example of how waste land is being reclaimed.

1. Find other instances where land is being restored for more productive use.
2. How is this being done?
3. Make suggestions for improving waste land in your area.

This book has probably helped you to become more familiar with the many properties of soil. This knowledge should help you attack the problems of soil conservation. The field trip that makes up this section will give you a chance to use what has been learned.

The next page shows a *partly used* tally guide for examining farmland. Make copies and use them to compare a good farm with an abandoned one. See if you can find out why the second farm was abandoned.

Can you think of other ways to use this guide? Would it be possible to use a similar method to study a watershed?

EXAMINATION OF FARMLAND

Location	Date	Name

	excellent	good	fair	poor	very poor
health of grass cover	✓	Copy the chart in your book. Do not write comments here.			
condition of trees		✓			
humus content in soil		✓			
moisture-holding capacity of soil	✓				
general health of plants being cultivated		✓			

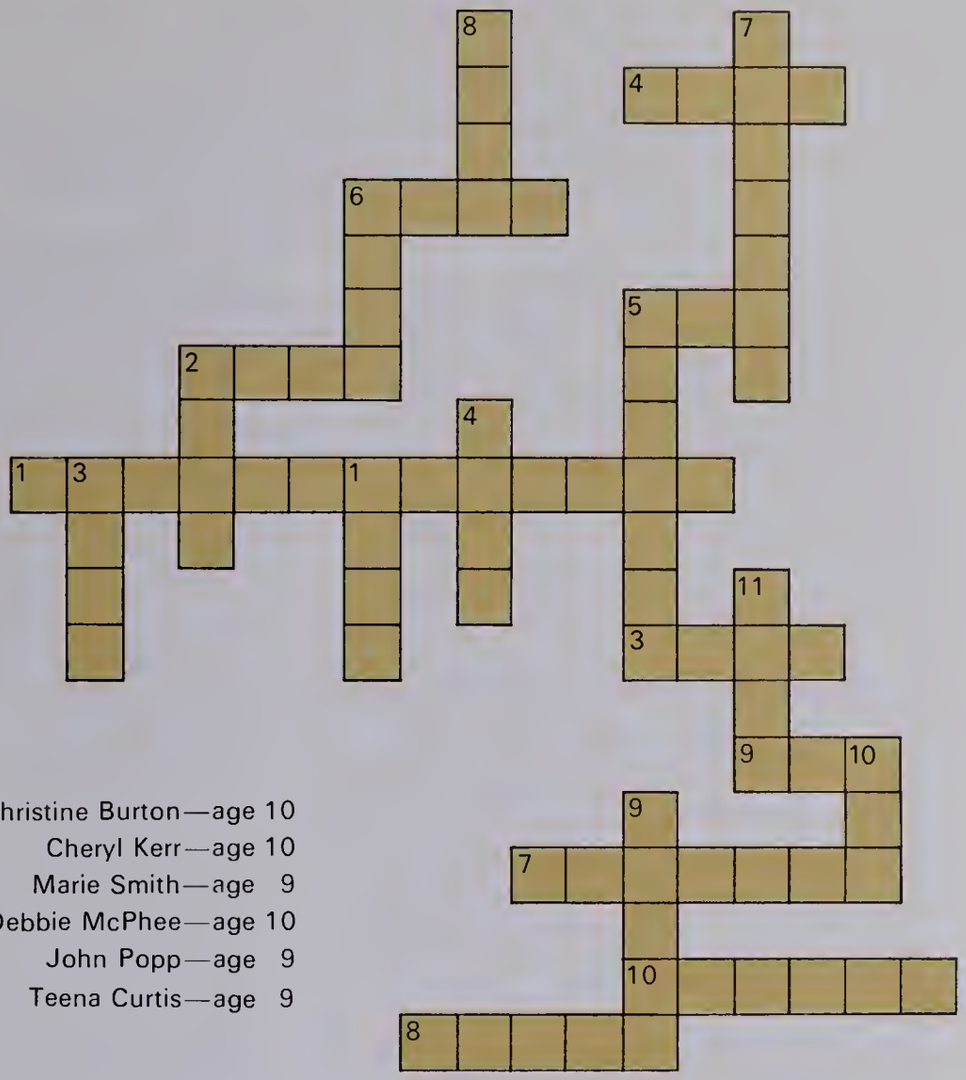
WAS THERE EVIDENCE OF	YES	NO	WAS THERE ANY EVIDENCE TO SUGGEST A NEED FOR: YES	NO
controlled drainage	✓			✓
sufficient drainage	✓			✓
terracing		✓		✓
contouring		✓		✓
irrigation		✓	✓	
pond and stream control		✓	✓	
furrowing				
windbreaks				
cover cropping				
stubble mulching				
strip cropping				
crop rotation				
fertilizing				
woodlot management				
controlled grazing				
muddy streams				
pollution				

The pile of stones tells a long story of a family's struggle to live off an unfriendly land.

After the terrible potato famines of the 1840's in Ireland, thousands of men, women and children left their homeland for Canada. Among them were the O'Neill family, attracted by the promise of free land across the ocean. They settled on the edge of the Canadian Shield, with difficulty carving out a farm from the woods and swamps. Everbody helped. The children collected the loose stones on the surface and made mounds. In some fields these mounds were every few yards, particularly as the plow was always turning up more stones.

The family planted wheat, and raised pigs and other animals. Over the years, it became harder and harder to make a living from the very poor soil. Three generations of O'Neills made the farm their home, but the family moved away to better land in the 1950's. Now the land is no longer farmed. There is little to remind anyone of the O'Neills except the old wooden farmhouse—and dozens of heaps of stones.

words to use
silt
insects
sand
leaf
ice
loam
rock
wind
glacier
lava
rain
clay
humus
loess
erosion
organic matter
snow
wet
tan
stream
worm



By Group 1

Christine Burton—age 10
Cheryl Kerr—age 10
Marie Smith—age 9
Debbie McPhee—age 10
John Popp—age 9
Teena Curtis—age 9

ACROSS

1 comes from living things
2 rhymes with roam
3 rhymes with hand
4 particles of soil
5 frozen water
6 moving air
7 rhymes with explosion
8 part of soil
9 opposite of dry
10 small river

DOWN

1 soil that is sticky when wet and hard when dry
2 grows on trees
3 rhymes with clock
4 comes from a volcano
5 flies are _____
6 he tumbles in the sand
7 a mountain of ice
8 precipitation
9 yellowish-brown soils
10 light brown
11 winter weather

Do not write your answers in this book.

Appendix

LEADER'S TASK CHART

This chart lists some of the things group leaders frequently do. Can you think of other things?

1. Understand the task	
2. Help others to understand the task	
3. Clarify questions and answers	
4. Organize group members and materials	
5. Assign different tasks	
6. Guide the group's planning	
7. Help the group to establish goals	
8. Provide encouragement for members	
9. Keep the group "on topic"	
10. Summarize information and ideas	
11. Organize record keeping	
12. Help each member to do his share	
13. Provide new ideas	
14. Participate to set a good example	
15. Make decisions	
16. Help people to work happily together	
17. Give praise for good work	
18. Act as group spokesman (sometimes)	
19. Set time schedules	
20. Evaluate work	
21. Arrange exchanges with other groups	
22. Accept criticism	
23.	
24.	

HOW WELL DO I WORK WITH OTHERS?

What things seem to make group work successful?

Use the following check list to judge how well you work with your group.

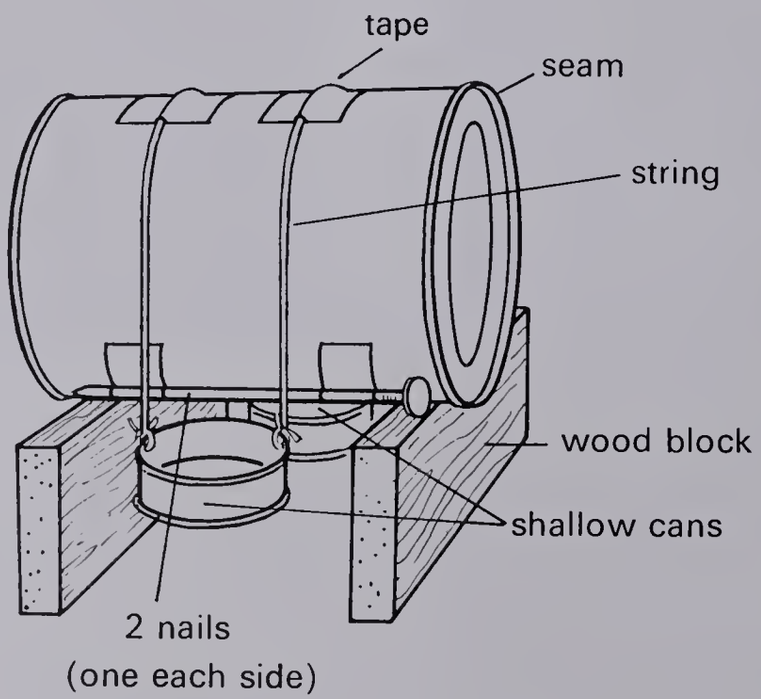
1. Co-operate and share materials									
2. Help to plan activities									
3. Speak distinctly and courteously									
4. Remain "on topic"									
5. Contribute worthwhile material									
6. Listen politely									
7. Respect other people									
8. Come prepared									
9. Locate new information									
10. Use several sources for information									
11. Make worthwhile notes									
12. Understand what is to be done									
13. Respect other people's ideas									
14. Avoid unnecessary repetition									
15. Work happily									
16. Support arguments sensibly									
17. Use several methods for reporting									

Much of the work in this book requires finding the masses of samples. You may be able to use commercial balances and standard weights. You can, however, make your own balances and use such things as iron washers as weights. The following diagrams give some ideas. Can you think of others?

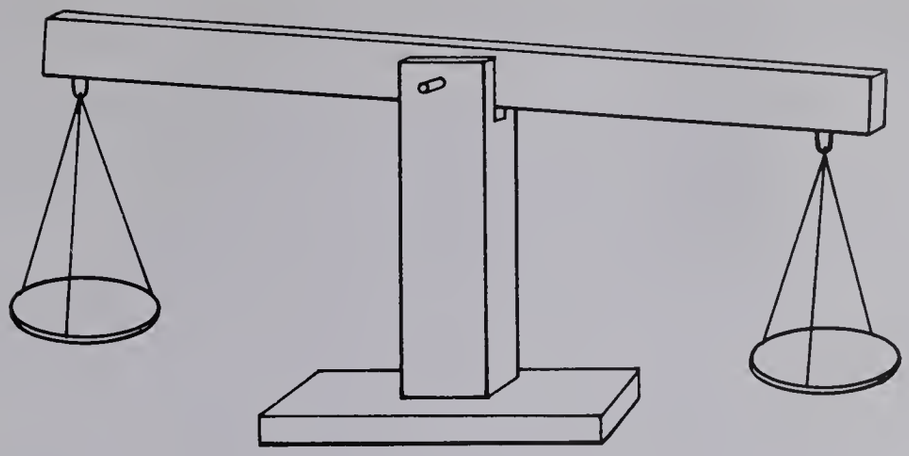
The Can Balance

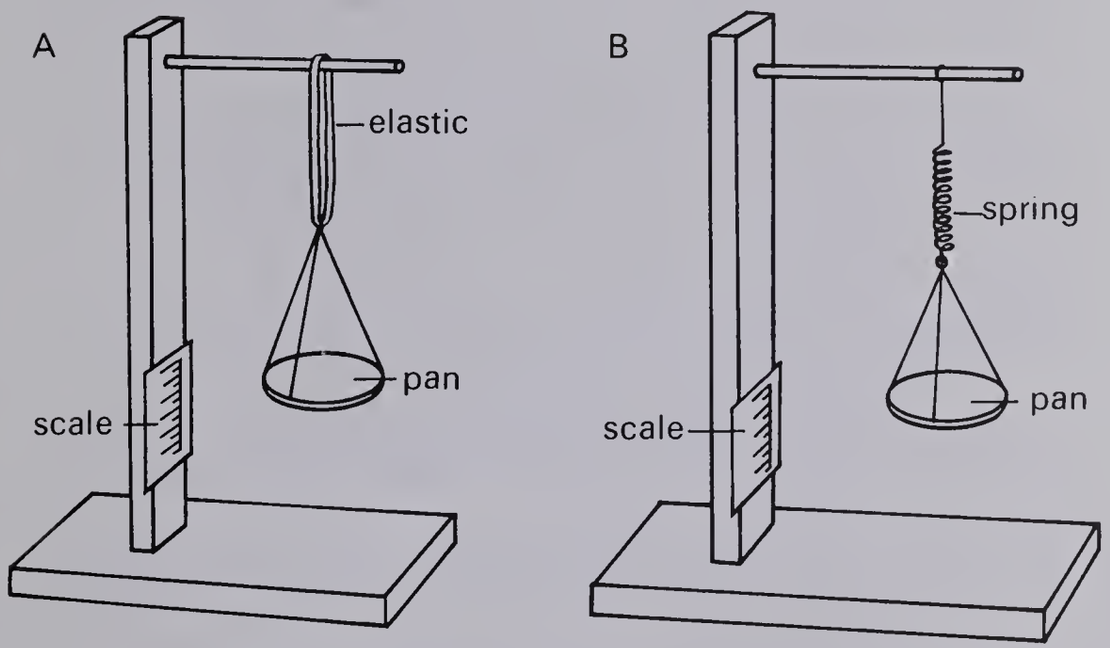
Use a large juice can to make this balance. Remove the label and tape a long nail opposite the seam of the can. Put the can on two blocks of wood of equal size so that it can roll freely until the seam comes to the top. Make the balance pans from two shallow cans of equal mass and balance them on the juice can using two pieces of string.

To compare the mass of two objects, simply place them in the hanging cans. To find the mass of one object, place it in one balance pan and add weights to the other.

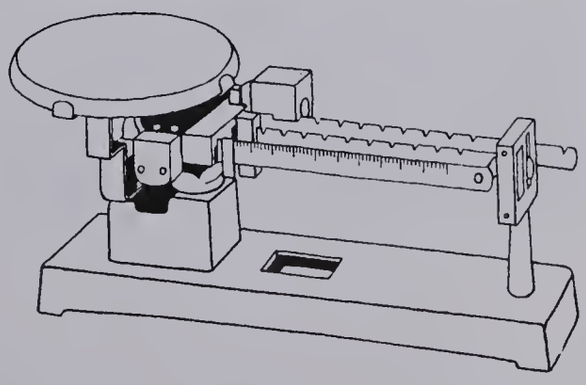


The Pan Balance





Triple Beam Balance



References

The federal and provincial publications in this bibliography are only a few of the relevant titles that are available from these sources.

Alberta Department of Agriculture, Field Crops Branch. *Gully Filling and Improving Water Courses*, Publication No. 176. Edmonton.

———, Radio and Information Branch. *Irrigation in Alberta*, Publication No. 156.

———, *Soil Management In Alberta*, Publication No. 510.

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Acknowledgments

Permission to reproduce illustrations and text material is gratefully acknowledged as follows.

Alberta Department of Agriculture, Plant Industry Division, 18, 89 (upper), 112, 116; Alberta Department of Industry and Tourism, 16 (lower); author, 13, 22, 26, 29, 62, 67, 89 (lower); Dr. D. M. Baird, National Museum of Science and Technology, 30, 56, 57 (lower), 58, 65; Dr. R. J. E. Brown, National Research Council, 69, 73; Canada Department of Agriculture, Information Division, 96 (left), 101, 103, 108, 109; Canadian Broadcasting Corporation, 110 ("The Deadly Mist", copyright © CBC TV, 5 February 1970); Dr. A. G. Edmund, Royal Ontario Museum, 66; Federation of Ontario Naturalists, 71 ("Warm in the Snow", reprinted from *The Young Naturalist*, December 1969); Grand River Conservation Authority, 115 (upper); P. K. Heringa, Canada Department of Agriculture, St. John's West, Newfoundland, 118; Ruth Holt, 59, 120; Dr. J. Mandarino, Royal Ontario Museum, 54; National Film Board, 90, 93; New Brunswick Travel Bureau, 61; *North Bay Nugget*, 68; Nuffield Foundation and Wm. Collins, Sons, & Co., Glasgow, 125 (in *Apparatus*, pages 179 and 180); Ontario Department of Agriculture and Food, 96 (right), 115 (lower), 117; Ontario Department of Highways, 70; Ontario Department of Tourism and Information, 81; Public Archives of Canada, 17; Steep Rock Iron Mines, 92 (left); Thunder Bay Tourist Association, 85 ("The Sleeping Giant"); Toronto Harbour Commissioners, 83; *Toronto Star* Syndicate, 76; Dr. W. M. Tovell, Royal Ontario Museum, 57 (upper), 92 (right); Dr. A. D. Tushingham, Royal Ontario Museum, 97; U.S. Department of Agriculture, Forest Service, 101 (Making Micromonoliths); U.S. Department of Agriculture, Soil Conservation Service, 74, 113; U.S. Department of the Interior, 114; Clive Webster, 111; Dr. T. C. Young, Royal Ontario Museum, 16 (upper); V. Zsilinszky, Ontario Department of Lands and Forests, 84.

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